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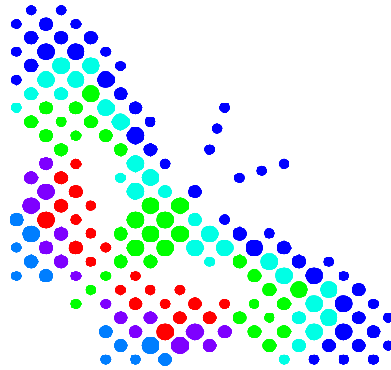
In-Situ Chemical Oxidation of PCE Files / Photographs
In-Situ Aerobic Biotreatment Progress Report (Sept 2005)

Ciba Specialty Chemicals Corporation
Corporate Remediation Services
Toms River, NJ

**SECOND PROGRESS REPORT
IN -SITU BIOTREATMENT
TOMS RIVER SITE
OPERABLE UNIT 2**

SUBMITTED BY

Ciba



SUBMITTED TO



**United States Environmental
Protection Agency**

PREPARED BY

**Ciba Specialty Chemicals
Corporate Remediation
Toms River, New Jersey
September 2005**

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1.0 Introduction

This is the second interim progress report that has been prepared to document the operations of the Phase 1 In-Situ Biotreatment process. The Phase 1 installation encompasses an area in the former East Equalization (EQ) Basin at the Toms River Site. This area was selected for the first phase of in-situ bio-treatment because it permits installation early in the overall OU2 project without interference from planned excavation in the former EQ Basins.

The biotreatment system for the former EQ Basins has been designed to be implemented in phases in order to coordinate with excavation activities in these areas. **Figure 1.1** shows the footprint of the former basins, the planned excavations for soils residing above the water table, and the three stages (Phase 1, Phase 2 and Phase 3) of the biotreatment process installation for treatment of the saturated zone soils. Phase 1 has been ongoing for two years. Phase 2 will be constructed in the fourth quarter of 2005, after the excavation activities are completed in the west EQ Basin. Phase 3 will be constructed after excavations are completed in the east EQ Basin. The current Phase 2/Phase 3 design will also incorporate three of the site Groundwater Extraction and Recharge (GERS) system wells (Wells 214, 215, and 216), to route this water to the in-situ biotreatment process instead of the Operable Unit 1 groundwater treatment facility.

The wells installed for the Phase 1 biotreatment will be incorporated into the subsequent larger systems that will be constructed after excavations are completed within the basins. Phase 1 consists of a single extraction well, a single re-injection well, and eleven (11) monitoring piezometers. **Figure 1.2** shows the location of the Phase 1 installation in the former East EQ Basin and the locations of the monitoring points. Twelve (12) monitoring piezometers are screened in the upper portion of the Primary Cohansey, and four (4) piezometers denoted with a "D" are screened in the bottom of the aquifer. Four of these monitoring points (PZ1-SGD, PZN-1, PZN-2, and PZN-3) were installed in 2004, after approximately one year of biotreatment process operation. These latest monitoring piezometers were installed to provide data on the north side of the East EQ Basin along the northern edge to help determine the limits of the Phase 1 treatment zone and better define the dissolved COC concentrations within the EQ Basin footprint.

Figure 1.3 shows the modeled groundwater flowpaths in the treatment area created by the Phase 1 pumping stress.

The construction specifications, instrumentation and process control for the Phase 1 operation has been documented previously in the design report for Operable Unit 2 and

also in the *Interim Report, In-Situ Biotreatment, Toms River Site, Operable Unit 2* (Ciba, May 2004).

The Phase 1 biotreatment has been operating for two years, during which time the groundwater elevations, dissolved oxygen, pH, contaminant concentrations, and dissolved chloride have been monitored both inside and outside of the treatment zone.

The extracted groundwater is routed through a control building where operational parameters are monitored and a 35% solution of hydrogen peroxide is added prior to the groundwater being re-injected. The recycled groundwater pH is also adjusted to >6.0 S.U. using a 25% sodium hydroxide solution.

The extraction well is approximately 100 feet downgradient of the re-injection well. The majority of groundwater re-injected at the upgradient location is expected to return to the extraction well to effect the groundwater “recycle”. The intermediate piezometers provide sampling points to assess local groundwater flow between the recirculation wells and monitor COC concentrations, groundwater pH, and dissolved oxygen levels in the subsurface.

2.0 Phase 1 Monitoring

2.1 Process Monitoring

Process monitoring includes groundwater recirculation rate, system operating pressure, and groundwater pH. These three parameters are monitored continuously using in-line probes with data recorded by a local PLC.

The piezometer locations are shown in **Figure 1.2**. These piezometers provide sample points for monitoring the oxygen distribution and oxygen uptake by the microbial community by providing monitoring points along the axis of groundwater travel from the re-injection well back to the extraction well. Groundwater COCs are measured on a monthly basis. Groundwater elevations, dissolved oxygen, and pH are measured on a bi-weekly schedule.

2.1.1 Dissolved Oxygen

Hydrogen peroxide usage from start up through the last sample date reported (6/27/05) was 9,100 gallons of 35% solution. Based on 18% oxygen by (mass) weight for a 35% solution (35% H₂O₂ weight is 10 lbs per gallon), this equates to 16,400 lbs of oxygen injected into the recycling groundwater over the two years of operation. The average rate oxygen delivery over this period was approximately 23 lbs per day. This dosage corresponds to 25 mg/l dissolved oxygen in the recycled groundwater upon re-injection.

Dissolved oxygen is measured in the piezometers inside and outside of the treatment zone by pumping groundwater under a low flow purge condition through a flow-through cell equipped with a dissolved oxygen probe. Groundwater elevation was monitored in each piezometer during an initial sampling event to determine the appropriate sample pumping rate for a low flow purge condition in which drawdown is minimized. Readings are taken after a minimum of 3 piezometer pore volumes are extracted and when the dissolved oxygen reading stabilizes. After the dissolved oxygen reading has been recorded a sample is collected for pH measurement.

Significant dissolved oxygen was not observed in the groundwater prior to adjusting the injected water pH above 6.0 S.U. Injection of peroxide alone, without first adjusting the pH above 6.0, did not increase the groundwater dissolved oxygen because the dissolution of peroxide to water and oxygen is inefficient at lower pH. Dissolved oxygen is measured within the treatment zone, as well as upgradient, side-gradient, and downgradient. Measurements are taken from a portable dissolved oxygen meter with a probe inserted into the flow through cell.

The estimated extent of dissolved oxygen based on monitoring data is shown in **Figure 2.1**, where the contour represents groundwater with dissolved oxygen >10 mg/l..

Included in **Figure 2.1** are concentric circles centered on the groundwater injection well. Assuming that the injected groundwater were distributed uniformly from the point of injection and unaffected by the direction of groundwater flow, these contours represent the aerial extent of the saturated zone water that is displaced over 3 days of groundwater injection at 65 GPM.

Dissolved oxygen >10 mg/l had been measured at all monitoring points within the contour in Figure 2.1, with most locations having concentrations in excess of 20 mg/l. All monitoring locations outside of the treatment zone (upgradient, side-gradient and downgradient locations) exhibit <0.2 mg/l dissolved oxygen in the groundwater.

The peroxide injection system was originally set to maintain a dosage of 100 ppm based on the groundwater recirculation rate. The control system program did not account for the peroxide dilution in the original commercial stock solution to 35%, and had incorrectly dosed peroxide at 30 ppm (as H₂O₂) for the first 18 months of operation. To maintain 100 ppm dosage as hydrogen peroxide, the correct feed for a 35% solution would actually be 286 ppm. This correction has been made, and the result was a significant increase in the oxygen concentration. Prior to the dosage correction significant dissolved oxygen was only reaching PZ-2 (50 feet downgradient if the injection well). The increase in the area of high dissolved oxygen is shown in Figure 2.1, with residual D.O. of up to 9 mg/l reaching the extraction well.

2.1.2 Groundwater pH

The groundwater pH within the treatment zone (PZ-1, PZ-2 and PZ-3) is shown in **Figure 2.2**, and the pH measured outside of the treatment area is shown in **Figure 2.3**. The groundwater pH in the treatment zone has increased from an initial condition of 3.8 S.U. to > 6.0 S.U. over most of the treatment zone. Below a pH of 6.0, dissociation of the peroxide to O₂ and H₂O is inefficient. The groundwater beneath the former EQ Basins exhibited a pH of 3.6 to 4.0 S.U. before adjustment.

The pH adjustment is by injection of a 25% sodium hydroxide solution into the recycled groundwater to increase the injected water pH to 6.2 S.U. The caustic solution is injected at the extraction well intake and controlled by a feedback loop that maintains the extracted groundwater at a pH of 6.2. The pH adjustment to >6.0 S.U. was required to provide efficient oxygenation of the groundwater using the peroxide. Currently the extracted groundwater pH is 6.0 S.U., and the groundwater pH is adjusted to 6.5 prior to re-injection.

Of note is the increase in groundwater pH at the upgradient piezometer, indicating that some reinjected groundwater may reach this upgradient location. The chloride ion data also shows increase at the upgradient location but the trend is not consistent (**Figure 2.3**).

2.1.3 Groundwater Elevations

Groundwater elevations have been measured in the piezometers and the extraction well to evaluate the local groundwater flow and assess the groundwater recirculation. The groundwater elevations are shown in **Figure 2.4**, which shows the groundwater gradient outside of the influence of the Phase 1 pumping system superimposed on the elevations measured within the influence of the pumping system. The drawdown observed in the extraction well is maintained at approximately four (4) ft, which is consistent with the groundwater modeling results used for the design.

Of particular note is that deep piezometers PZ-1D and PZ1-SGD (**Figure 1.2**), which are screened a few feet above the Cohansey/Kirkwood Transition Unit at the bottom of the treatment zone, are both under sufficient hydraulic pressure to intermittently produce a slow flow out of the top of the riser tubes (i.e., artesian conditions), which terminate approximately 4 inches above the ground surface. This pressure gradient between the deep and shallow piezometers is not observed at the location of PZ-3 and PZ-3D, which is seventy five (75) feet downgradient of the point of injection. The cause of this high

pressure deep in the Cohansey aquifer is unresolved. However, a layer of iron-cemented sand at some depth between the screened intervals of the nested piezometers near the injection well is suspected to cause the deep confined pressure. This potential heterogeneity probably does not affect the lateral flow and “sweep efficiency” of the biotreatment process because of the COC reductions observed in monitoring piezometers across the area. This data is shown in Table 2.1 and Table 2.2.

2.1.4 Dissolved Carbon Dioxide

Dissolved carbon dioxide, measured in February 2005, ranges from 18 mg/l in the upgradient piezometer (PZ-UG) to 10 mg/l downgradient of the treatment area. The dissolved CO₂ within the treatment area is within the range of 12 to 13 mg/l in all the monitoring locations. These levels have not changed significantly over time.

2.1.5 Total Dissolved Solids (TDS)

TDS measurements at locations within and outside of the treatment zone do not show significant increase due to groundwater pH adjustment or biotreatment reactions. Dissolved solids upgradient and side-gradient of the treatment zone are approximately 80 mg/l, and within the treatment zone the dissolved solids average 200 mg/l. This level of dissolved solids is not expected to cause any inhibitory effect to the biotreatment process.

2.2 Phase 1 Performance Monitoring

2.2.1 Groundwater COCs

Performance monitoring includes sampling of the recirculated groundwater and the piezometers both inside and outside of the treatment area for site COCs. Concentration trends for individual COCs over time are shown in **Figure 2.5**, **Figure 2.6**, and **Figure 2.8** and described below.

Figure 2.5 shows groundwater concentration data for 1,2-dichlorobenzene, 2-chlorotoluene, and 1,2,4-trichlorobenzene at piezometers PZ-1, PZ-2, and PZ-3, which are 25, 50, and 75 feet downgradient, respectively, of the groundwater injection well. These three COCs represented >90% of the dissolved total COC mass at the time of start-up. Significant reductions have been observed over time in these three wells.

Table 2.1 shows a comparison between the chlorinated benzenes during the first three months of system operational monitoring versus the most recent 3 months. These comparisons are made at the monitoring locations PZ-1, PZ-2, and PZ-3, which are

located along the axis of groundwater travel from the point of groundwater injection back to the point of extraction. Significant reductions in these compounds are evident at all three monitoring locations based on comparison of the initial data to the most recent measurements.

Table 2.1 – Reductions in Dissolved Chlorinated Benzenes (PZ-1, PZ-2, PZ-3)

PZ-1 25 ft Downgradient (ug/l)	First 3 months	Last 3 months	Percent Change
2-Chlorotoluene	9243	569	-94%
1,2-Dichlorobenzene	11002	286	-97%
1,2,4-Trichlorobenzene	3162	833	-74%
Aliphatics (TCE + PCE + TCP)	994	2416	143%

PZ-2 50 ft Downgradient (ug/l)			
2-Chlorotoluene	8097	251	-97%
1,2-Dichlorobenzene	7933	86	-99%
1,2,4-Trichlorobenzene	3240	337	-90%
Aliphatics (TCE + PCE + TCP)	984	2610	165%

PZ-3 75 ft Downgradient (ug/l)			
2-Chlorotoluene	9171	1834	-80%
1,2-Dichlorobenzene	11061	1501	-86%
1,2,4-Trichlorobenzene	3415	1051	-69%
Aliphatics (TCE + PCE + TCP)	927	2660	187%

The piezometers installed in along the northern edge of the basin in 2004 show similar reductions in the chlorinated benzenes. This is shown in **Table 2.2**. The north side piezometers also show significant reductions in the dissolved chlorinated benzenes. The COC reductions, high dissolved oxygen, and increase in groundwater pH at these monitoring locations indicate the zone of influence of the Phase 1 biotreatment system is larger than anticipated

Table 2.2 - Reductions in Dissolved Chlorinated Benzenes (PZ-N1, PZ-N2, PZ-N3)

PZ-N1	6/18/04	11/8/04	2/27/05	4/19/05	5/12/05	6/20/05	8/5/05
2-Chlorotoluene	17410	3635	2142	1004	629	424	430
1,2-Dichlorobenzene	15922	2664	1382	641	2842	269	293
1,2,4-Trichlorobenzene	10264	9121	10073	6276	ND	1181	2937

PZ-N2	6/18/04	11/8/04	2/27/05	4/19/05	5/12/05	6/20/05	8/5/05
2-Chlorotoluene	1270	729	1254	277	46	903	881
1,2-Dichlorobenzene	490	224	861	189	23	332	435
1,2,4-Trichlorobenzene	7313	7229	6501	4553	547	385	1063

PZ-N3	6/18/04	11/8/04	2/27/05	4/19/05	5/12/05	6/20/05	8/5/05
2-Chlorotoluene	1320	491	992	294	60	172	343
1,2-Dichlorobenzene	413	206	699	4317	33	51	188
1,2,4-Trichlorobenzene	7359	6026	4363	39	363	132	112

Figure 2.6 shows the same date trends as shown in **Figure 2.5** for the wells that lie outside of the treatment area. The upgradient, side-gradient, and downgradient locations do not show reductions in COC concentrations.

Figure 2.7 shows a comparison of TVOS data from the monitoring point upgradient plotted with the mean of the TVOS data from the three piezometers along the axis between the point of groundwater injection and extraction (PZ-1, PZ-2, and PZ-3).

Figure 2.8 shows the mean concentration of the primary aliphatics (TCE + PCE) within the treatment area, calculated using the data from PZ-1, PZ-2, and PZ-3.

The reductions in the dissolved concentrations of chlorinated benzenes (1,2-dichlorobenzene, 2-chlorotoluene, and 1,2,4-trichlorobenzene) have been coupled with a corresponding increase in dissolved aliphatics (Table 2.1). Tetrachloroethene (PCE) accounts for the increase in dissolved aliphatics, as shown in **Figure 2.8**. The aliphatic contribution to the total volatile organics measured in the groundwater has increased from 4% to 55% because of the significant decrease in the more degradable chlorinated benzenes, and the likelihood that the solubility of PCE has increased in the groundwater because of its now higher mole fraction. The groundwater recirculation also has the potential to concentrate the aliphatics which are not amenable to aerobic degradation.

2.2.2 Chloride Ion/COC Balance

Chloride ion concentration in groundwater has been tracked within the treatment area as well as upgradient, side-gradient, and downgradient. Treatment zone groundwater

chloride ion concentration has increased to 77 mg/l. The data trend for the chloride ion in the groundwater within the treatment area is shown in **Figure 2.9**.

The chloride ion data at the upgradient and downgradient piezometers has significant fluctuations in the data, as shown in **Figure 2.10**. The chloride concentration in the side-gradient piezometer has remained stable throughout the period of operation. Additional groundwater modeling of water elevation data is required to determine whether the chloride fluctuation at the upgradient piezometer could be a result of influence from the treatment system.

Calculation of the treatment zone total volume and water filled volume are used to estimate the mass of COCs and chloride ion. Based on the treatment zone saturated volume of 243,000 ft³ (Based on the oxygenated area shown in Figure 2.1) x (40 ft saturated depth), a saturated porosity of 0.35 and 7.48 gallons per ft³, there are approximately 636,000 gallons of groundwater within the treatment area between the injection and the extraction well.

The recycled groundwater COC concentration at start up had a mean total volatile organic concentration of 30 mg/l. Using this mean COC concentration distributed throughout the 636,000 gallons of groundwater :

$$(636,000\text{Gal}) \times (3.785 \text{ liters/gal}) \times (30 \text{ mg/l TVOS}) \times (454,000 \text{ mg/lb}) = 159 \text{ lbs Dissolved TVOS}$$

The 159 lbs of TVOS represents the dissolved COC mass distributed in the treatment zone at the start of the biotreatment process.

The chloride ion release from biotreatment is calculated as:

$$(636,000\text{Gal}) \times (3.785 \text{ liters/gal}) \times (66 \text{ mg/l Cl}^- \text{ increase}) / (454,000 \text{ mg/lb}) = 350 \text{ lbs Cl}^-$$

Using the calculated chloride ion increase within the treatment area, the corresponding COC mass is calculated based on the percentages shown in **Table 2.3**.

Table 2.3**COC Chloride Percentage for Mass Calculations**

Analyte	%Cl-	Weight factor as % TVOS*	Representative Cl- contribution (%)
1,2,4-Trichlorobenzene	58.60%	23	13.5
1,2-Dichlorobenzene	48.20%	38.5	18.6
2-Chlorotoluene	28.00%	38.5	10.8
Total			42.8

* Weight Factor for these 3 analytes is normalized to 100%

$$(350 \text{ lbs Cl-}) / (0.428 \text{ Cl-}) = 818 \text{ lbs COCs degraded.}$$

This represents a gross estimate of COC mass that has been degraded within the treatment area, and does show that there is continuing mass flux to the groundwater from source material.

The data from the downgradient piezometer shows an increase in chloride ion concentration, indicating that there may be significant degradation of COCs in water that is outside of the currently estimated treatment zone extent. The Phase 1 operation is not designed to capture all of the injected groundwater, and the increase in chloride ion seen in the downgradient piezometer (and potentially upgradient) is not unexpected based on the travel time from the treatment zone to the downgradient piezometer under the natural groundwater horizontal velocity of approximately one (1) foot per day.

The mass of oxygen delivered (**Section 2.1.1**) is 16,400 lbs. Dividing this value by the 818 lbs of degraded COCs shows a gross estimate of 20:1 oxygen to COC ratio. Estimation based on theoretical oxygen demand (THOD) for a generic COC formula based on the literature is 3.2:1 oxygen to organic COC on a molar basis. The high ratio of 20:1 for the Phase 1 operation is likely due to non-target analytes and naturally present BOD within the aquifer, both organic and inorganic, as well as oxygen utilization beyond the treatment zone along the axis between the point of injection and the extractions well downgradient.

3.0 Phase 1 Data Analysis and Future Work

Reduction in the groundwater COC concentrations has been significant and is consistent among the monitoring wells within the treatment zone.

With degradation of the dissolved COC evident based on dissolved oxygen uptake, chloride ion increase and changes in concentrations of individual COCs, the chlorinated benzenes in the groundwater are expected to continue to decrease in concentration. Because the PCE concentration is now significant (greater than 2 mg/l) relative to the remaining groundwater total volatile organic concentration, future work will focus on efforts to degrade this, as well as other aliphatic compounds. There is no aerobic pathway for PCE, so a change in treatment strategy will be required to reduce this contaminant to acceptable levels. Trichloropropane (1,2,3-TCP) is also present in the groundwater at concentrations of 0.5 mg/l. TCP is not expected to degrade through aerobic or anaerobic biotreatment processes. The treatment strategy for future reduction of the aliphatics will focus on chemical oxidation in the dissolved phase, once the aerobically degradable COC (chlorinated benzenes) and non-target oxygen demand has been reduced to the extent practicable by the current biotreatment system. Bench testing will be the first effort undertaken to evaluate the potential for chemical oxidation of dissolved recalcitrant aliphatics.

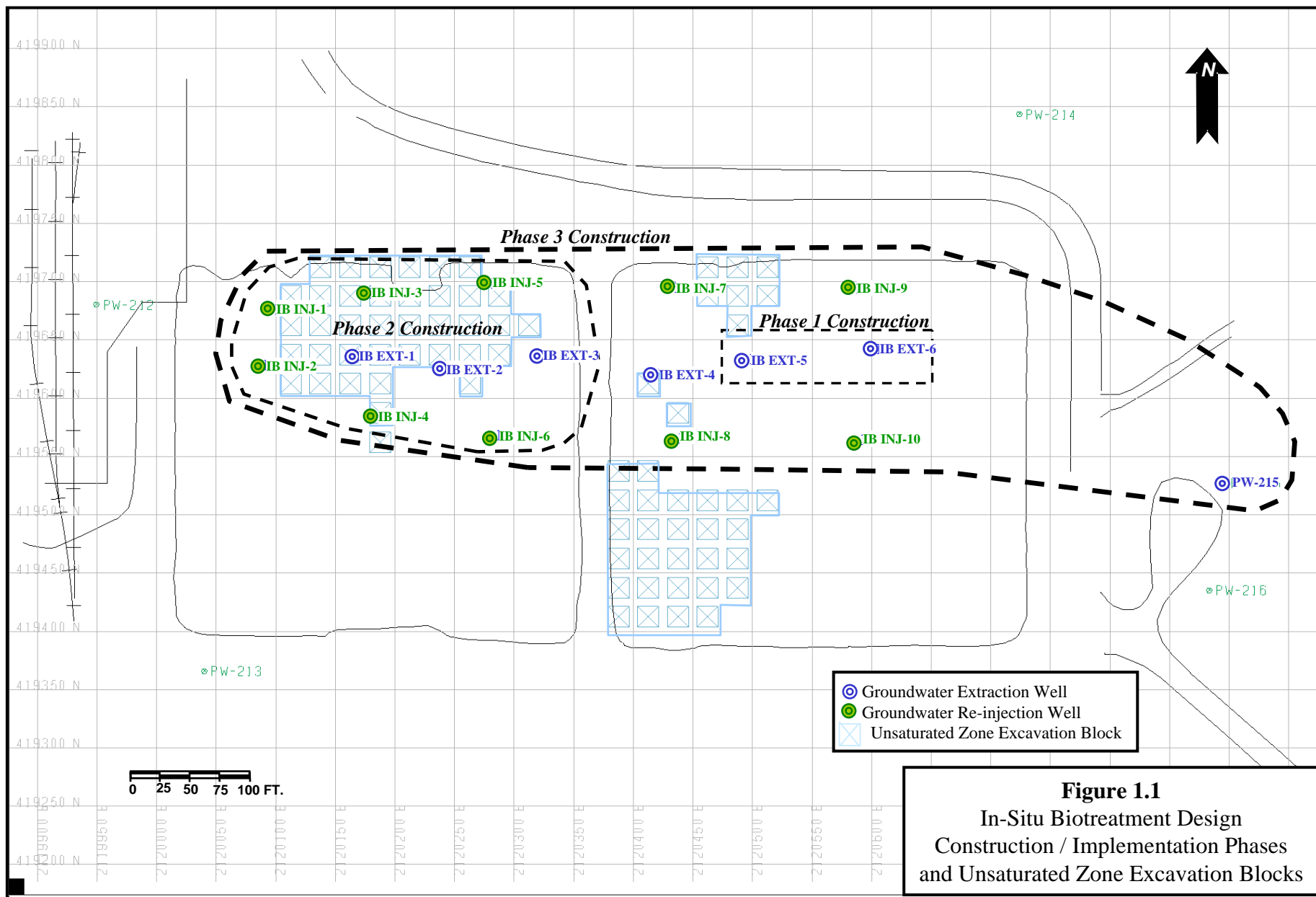


Figure 1.1
In-Situ Biotreatment Design
Construction / Implementation Phases
and Unsaturated Zone Excavation Blocks

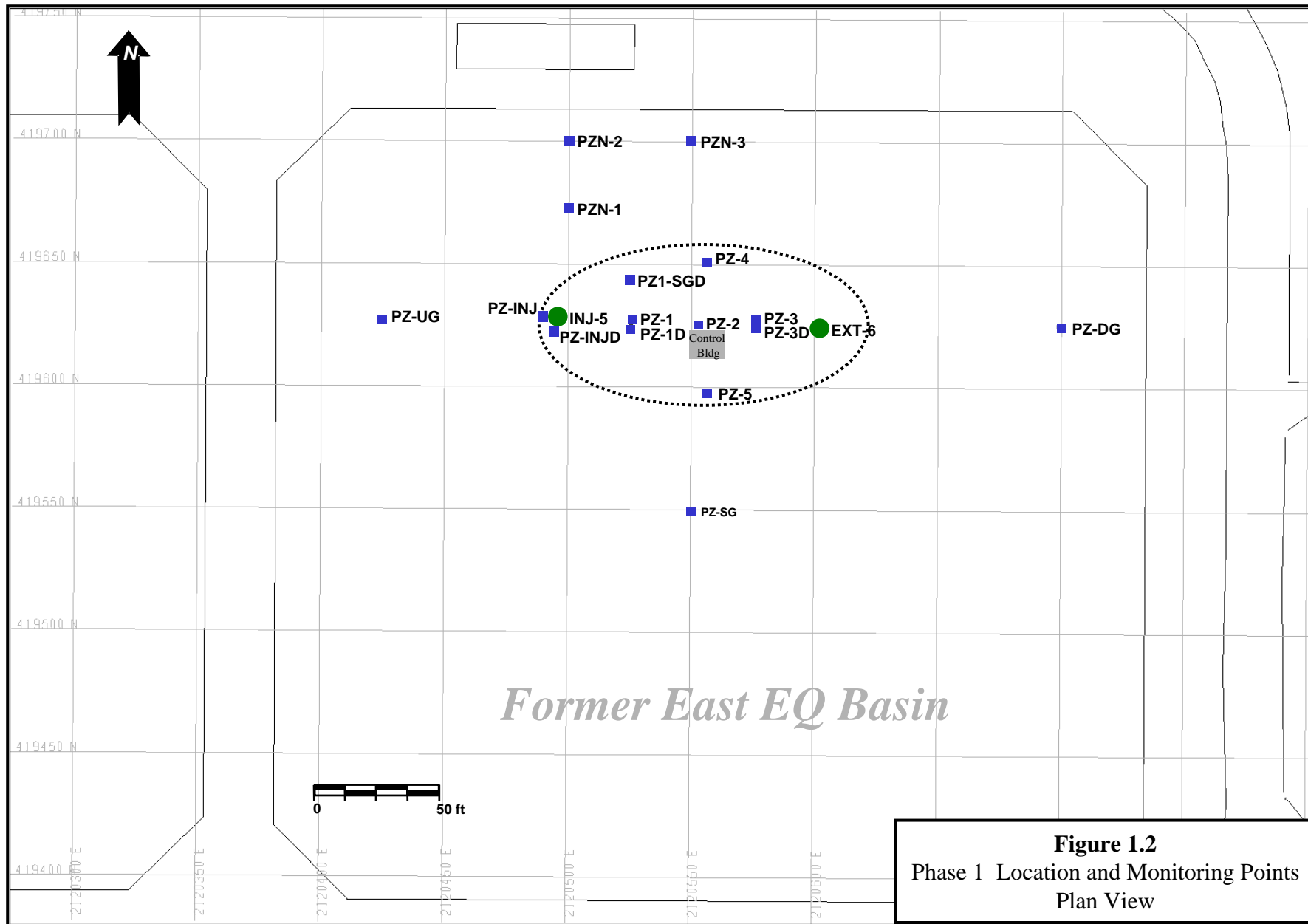


Figure 1.2
Phase 1 Location and Monitoring Points
Plan View

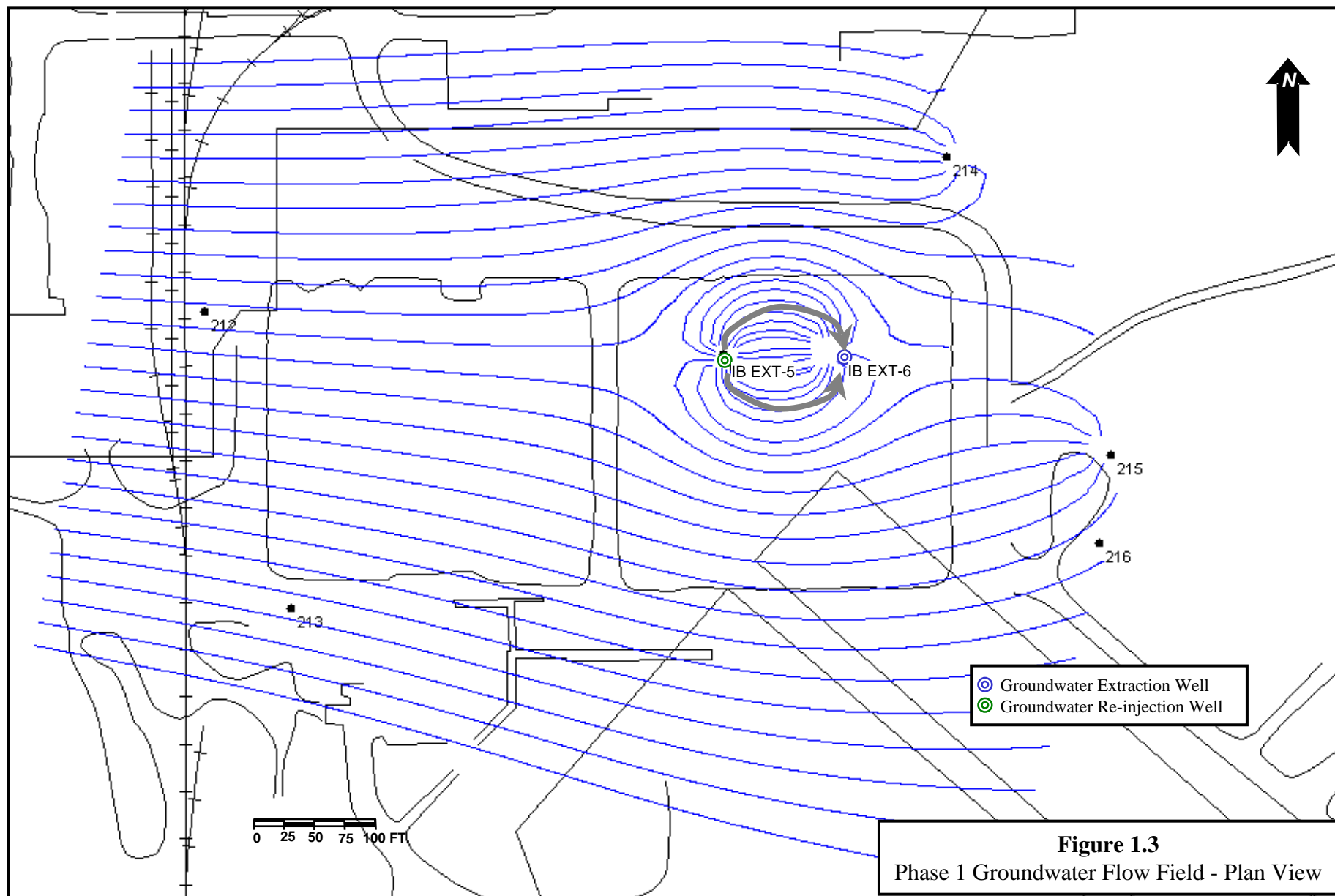


Figure 1.3
Phase 1 Groundwater Flow Field - Plan View

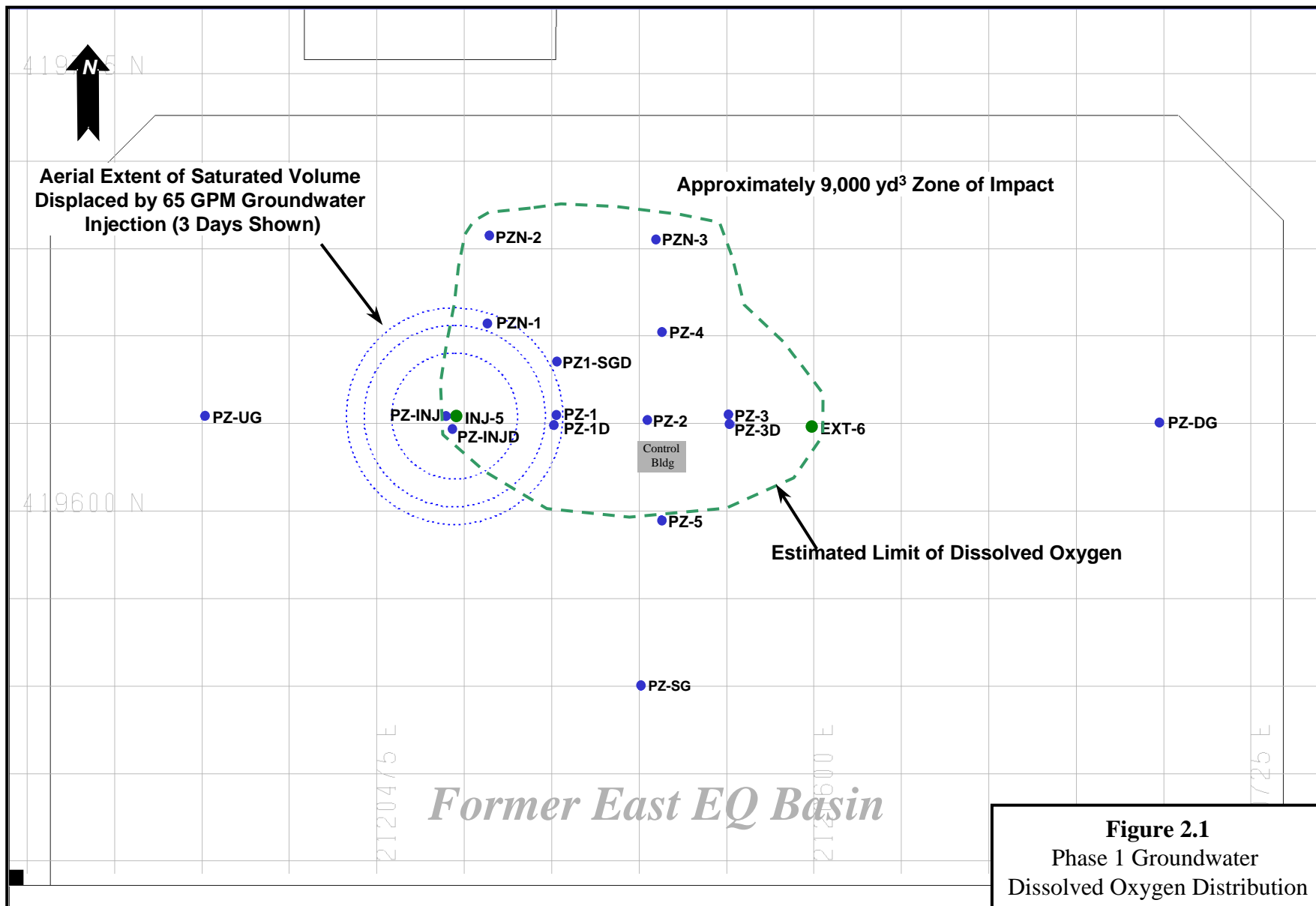


Figure 2.1
Phase 1 Groundwater
Dissolved Oxygen Distribution

Figure 2.2
Groundwater pH Inside Treatment Area

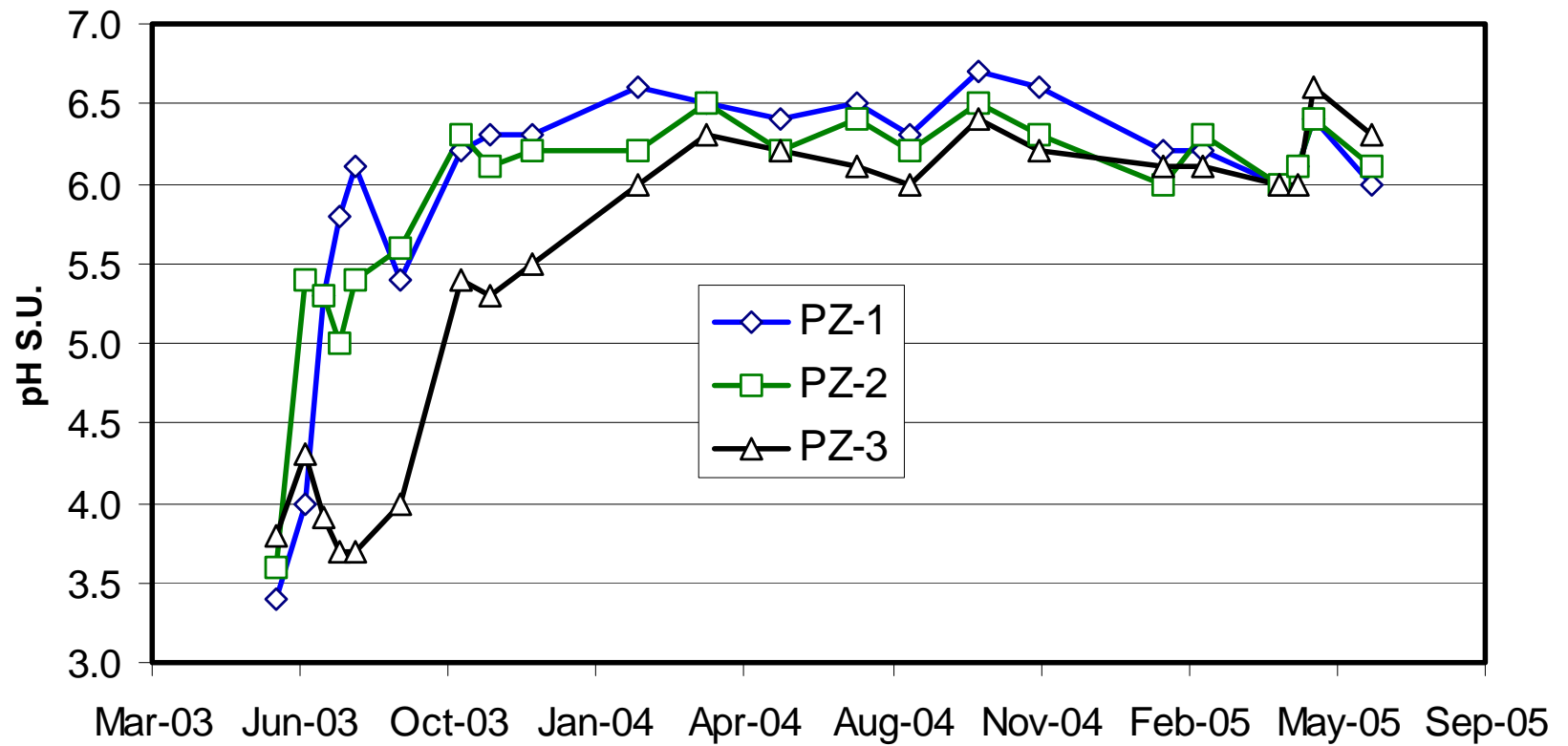


Figure 2.3
Groundwater pH Outside Treatment Area

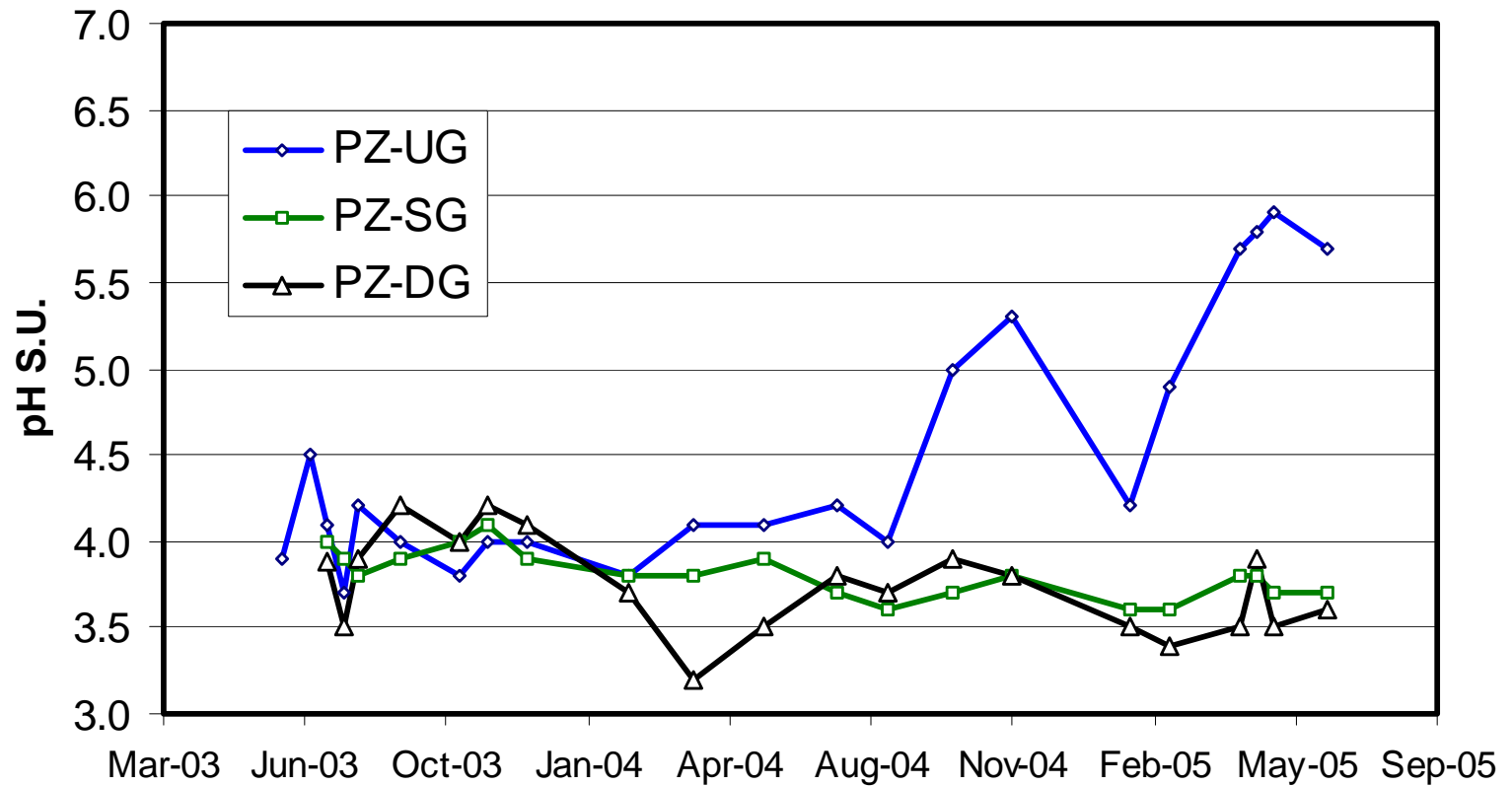
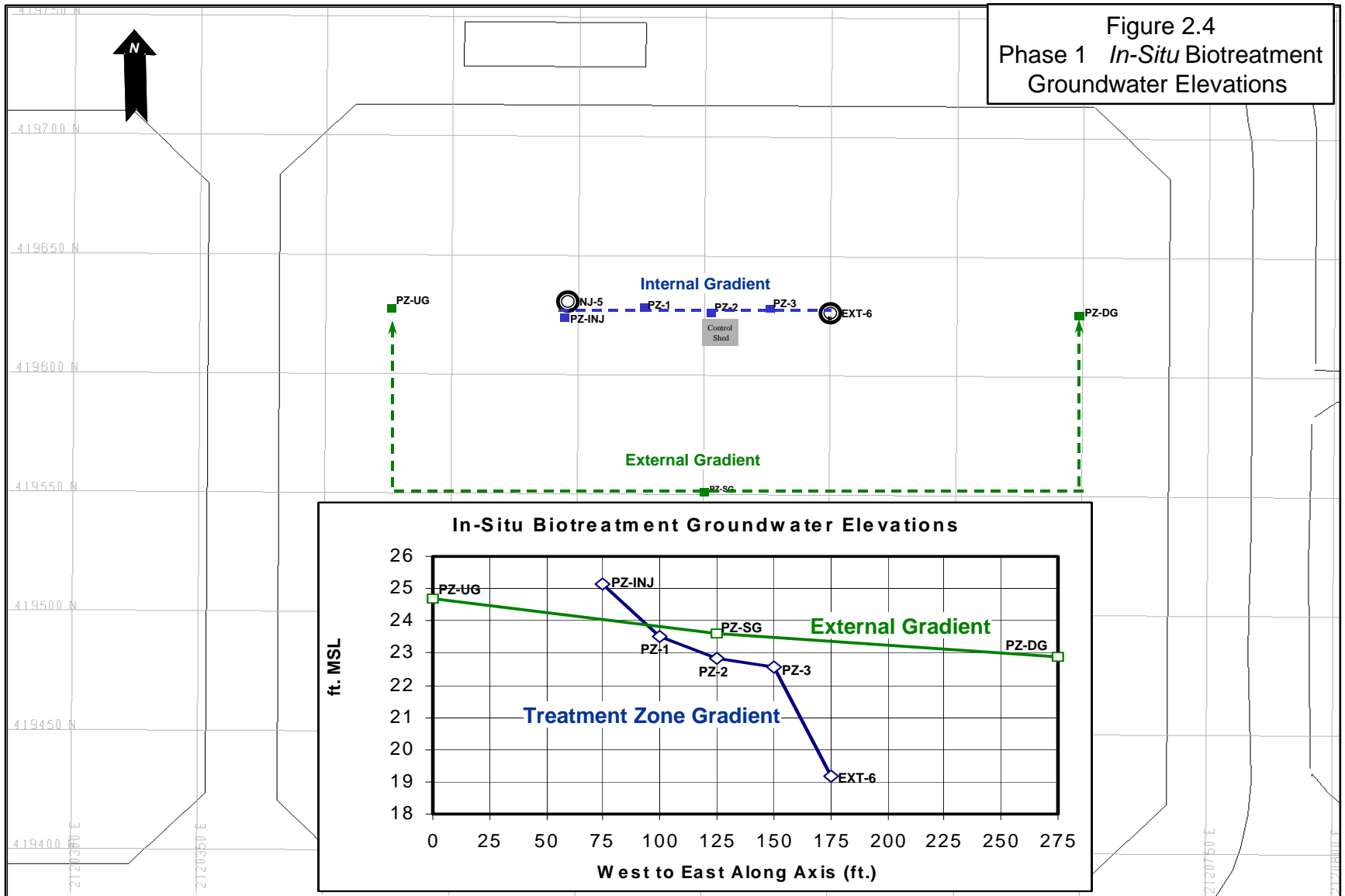
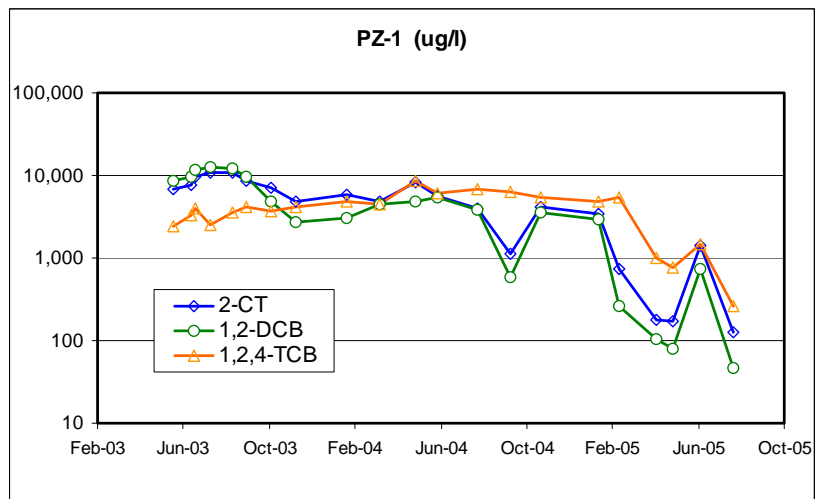


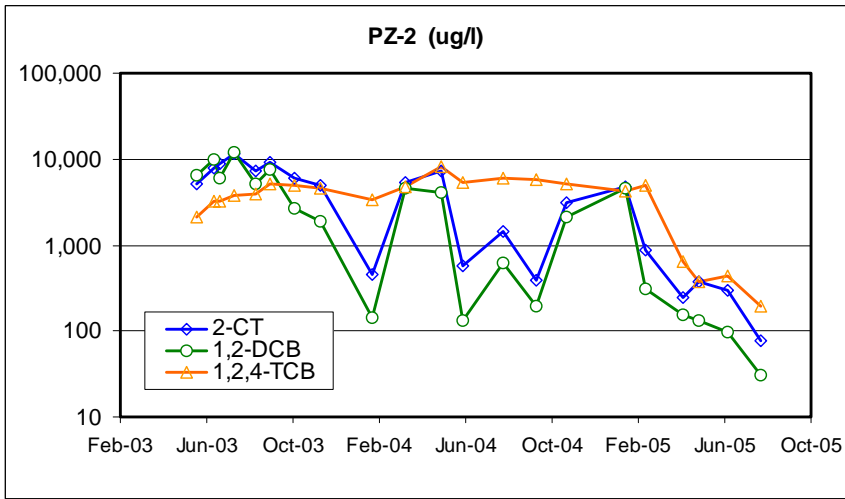
Figure 2.4
Phase 1 *In-Situ* Biotreatment
Groundwater Elevations



25 Feet from Injection



50 Feet from Injection



75 Feet from Injection

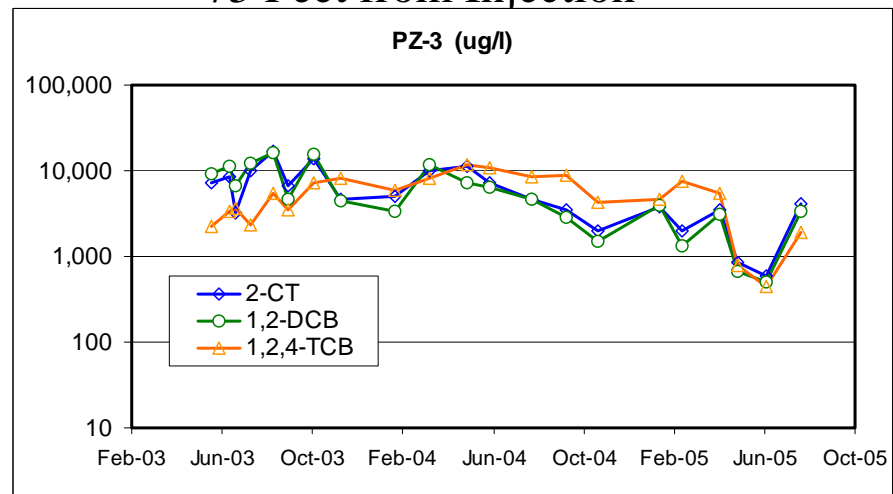
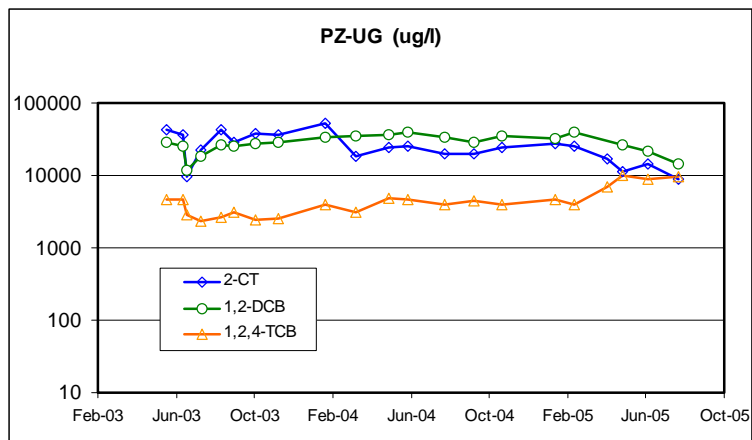
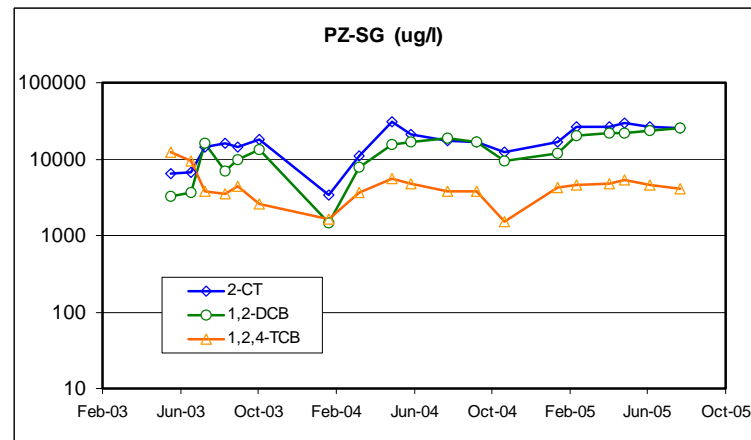


Figure 2.5
Phase 1 Groundwater
Chlorinated Benzenes
Outside of Treatment Zone

Upgradient of Treatment Zone



Side-gradient of Treatment Zone



Downgradient of Treatment Zone

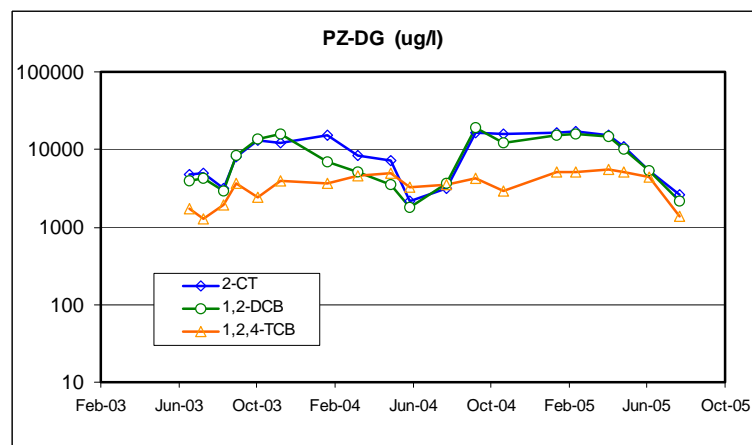


Figure 2.6
Phase 1 Groundwater
PZ-1 / PZ-2 / PZ-3
Chlorinated Benzenes

Figure 2.7
Groundwater TVOS (mg/l)

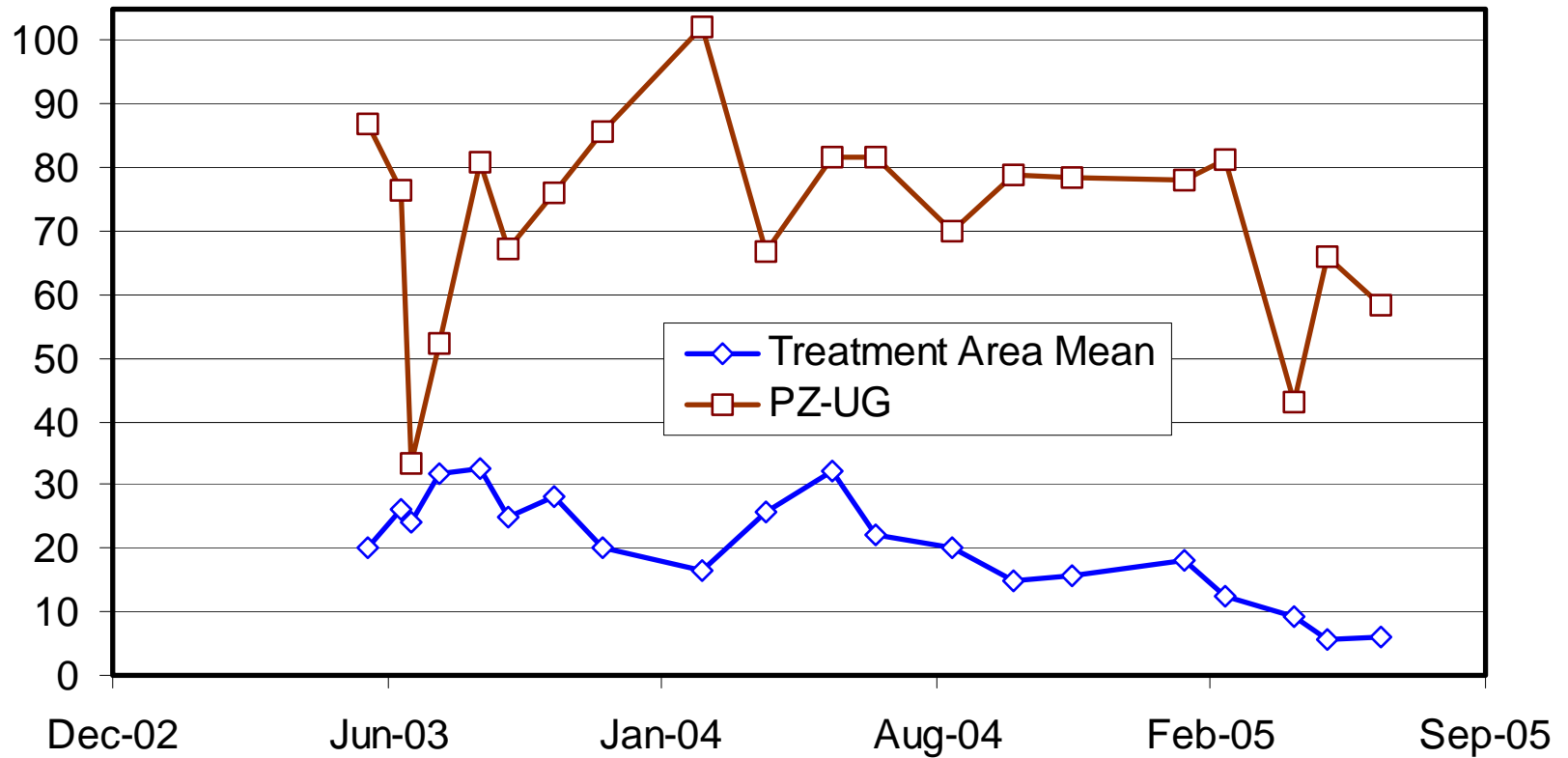


Figure 2.8
Treatment Area Mean
TCE PCE TCP (ug/l)

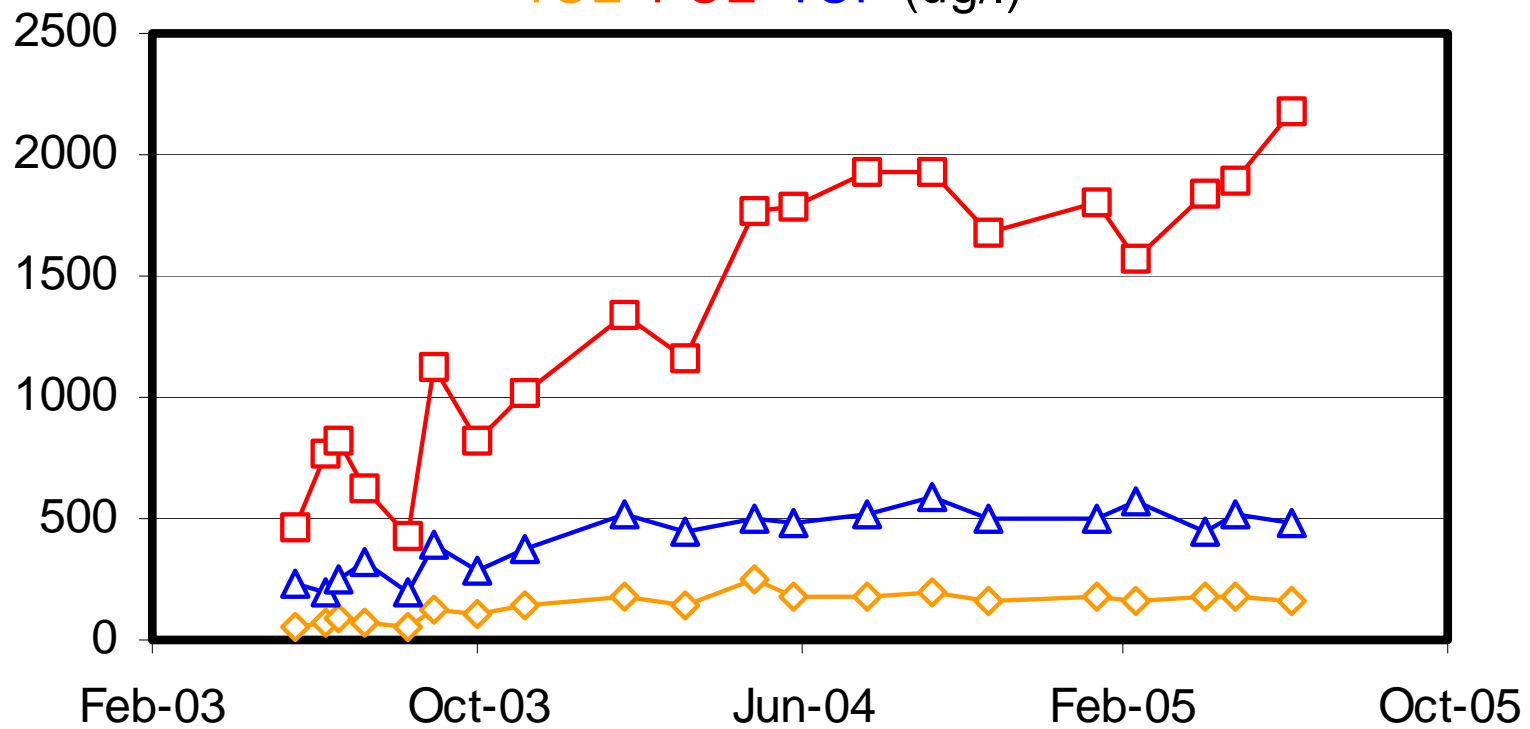


Figure 2.9
Treatment Area Dissolved Chloride Concentration (mg/l)

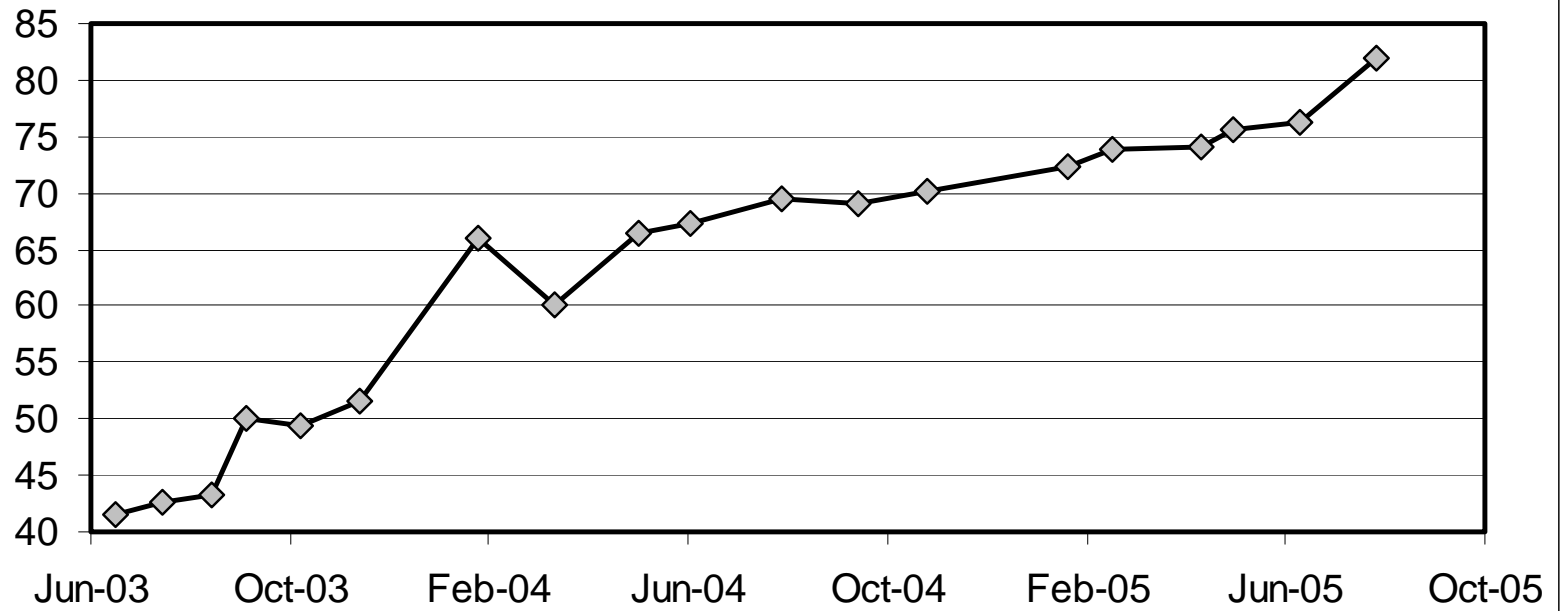
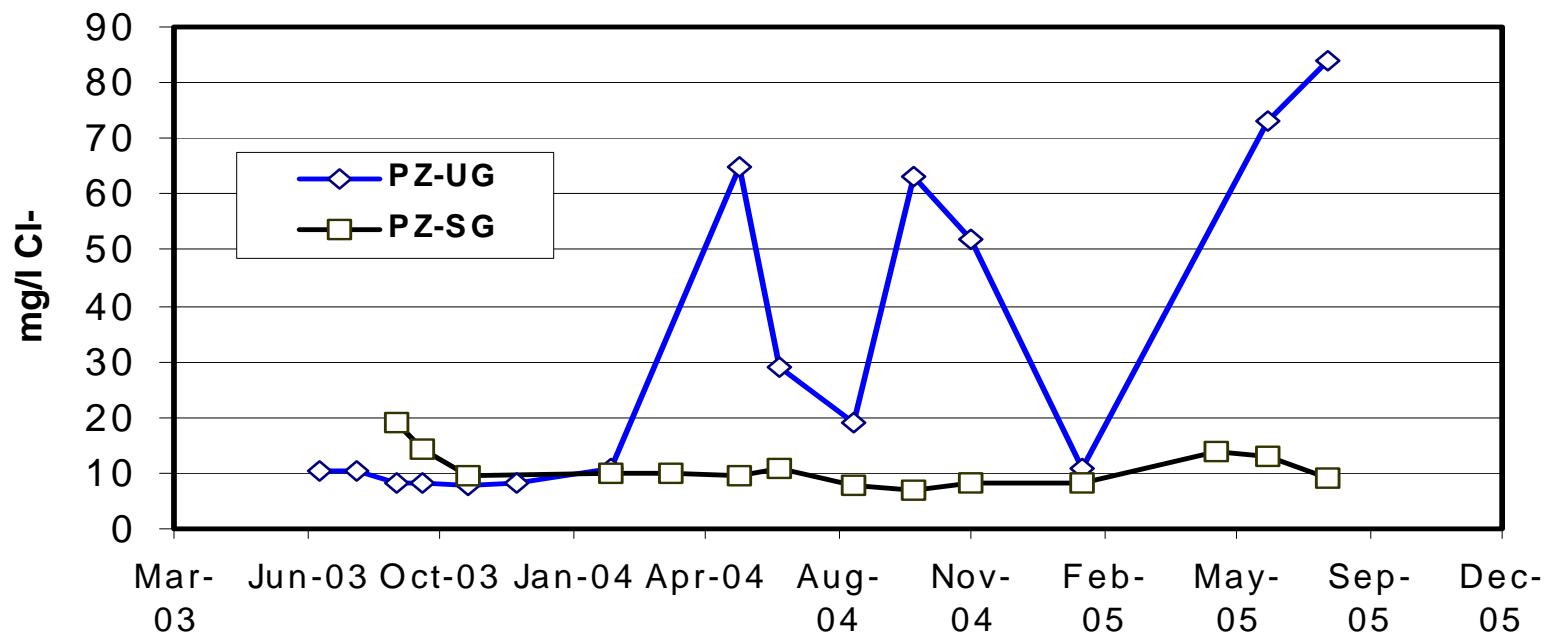


Figure 2.10
Upgradient and Side-Gradient Dissolved Chloride



**Revised Remedial Action Evaluation / Implementation
Plan for Soil In the Former Plourde-Lyons Area
Hamblet & Hayes Site
Lewiston, Maine**

SUBMITTED BY

Ciba



SUBMITTED TO

**State of Maine
Department of Environmental Protection
Division of Oil & Hazardous Waste Facilities Regulation
Bureau of Remediation & Waste Management**

PREPARED BY

**Ciba Specialty Chemicals
Corporate Remediation
Toms River, New Jersey
October 29, 2001**

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1.0 INTRODUCTION

Ciba Specialty Chemicals Corporation (Ciba) contracted ABB Environmental Services, Inc. (ABB-ES) to prepare a Remedial Action Evaluation (RAE) to evaluate alternatives for remediation of contaminated soils in the former Plourde/Lyons area at the Hamblet & Hayes (H&H) Site in Lewiston, Maine. The draft document was submitted to MEDEP in 1997. Based on MEDEP comments on the draft report and continuing investigation and technology evaluations, Ciba has revised the document prior to submittal.

Contaminated soil at the former Plourde/Lyons area identified in previous Site Investigations is present from former discharges that occurred at the H&H Site. Since 1991, when contaminants were first detected in this area, Ciba has worked in cooperation with the Maine Department of Environmental Protection (MEDEP) to determine the extent of contamination and develop appropriate measures for corrective action. This evaluation was conducted to fulfill one of the requirements included in the Compliance Order for the H&H Site issued by the MEDEP (MEDEP, 1997a).

The Compliance Order required Ciba to submit a detailed evaluation and recommendations for remedial actions for the contaminated soils identified south of the truck loading warehouse (i.e., the former Plourde/Lyons area). The evaluation considered alternatives including direct removal of the soils and on site treatment of the soils. The evaluation examined in detail the protectiveness of human health and the environment; long-term reliability and effectiveness; reduction of toxicity, mobility, or volume; implementability; and cost for these actions. The Compliance Order also made allowances for inclusion of alternative remedial strategies, including institutional controls in the evaluation.

This revised RAE is part of the corrective actions conducted for the Site. The previously implemented actions included:

1. A soil vapor extraction (SVE) and air sparging system to remediate contaminated soil and groundwater in a former underground storage tank area;
2. Groundwater extraction, treatment, and monitoring activities (discussed in **Section 2.4**) for the contaminated groundwater at the H&H Site.

This revised RAE was prepared utilizing the original draft document that was submitted to MEDEP in 1997, incorporating MEDEP comments and includes current understanding based on evaluation of the additional bench and pilot testing conducted by Ciba in 1998 and 1999. Additional samples were also

collected to better define the nature and extent of the contamination in the Plourde-Lyons area in several phases conducted from 1998 through 2000. The revised report consists of a discussion of the following:

- Summary of Current Site Conditions including geology, hydrogeology, soil contamination, and ongoing remedial activities (Section 2.0);
- Corrective Action Objectives (Section 3.0);
- Potential Remedial Alternatives (Section 4.0); and
- Evaluation of Alternatives (Section 5.0).

2.0 SUMMARY OF CURRENT SITE CONDITIONS

A general Site location map is provided as **Figure 1**. **Figure 2** shows the location of Plourde/Lyons area south of the warehouse where this remedial action is focused.

Soil and groundwater investigations were conducted in the former Plourde/Lyons area of the H&H Site as part of the SI conducted from 1989 through 2000. The SI program consisted of four phases of investigations and additional sample events in the Plourde/Lyons area south of the Truck Loading Warehouse. During Phase IV and subsequent sampling events, specific tasks were undertaken to assess the nature and extent of site-derived contamination and the hydrogeologic conditions in that area. Investigations assessed conditions above the deep sand and gravel aquifer that underlies the area, with the focus of remedial action on protecting the sand and gravel aquifer.

The following paragraphs summarize the information obtained during the SI for the former Plourde/Lyons area.

2.1 Geology

Geology in the former Plourde/Lyons area was interpreted from borings installed in the area. Subsurface exploration locations conducted in the former Plourde/Lyons area are shown on **Figure 3**. An interpretation of the geology south of the Warehouse is shown in two geologic profiles located and oriented as shown in **Figure 4** (profile Y-Y', generally north-south; profile X-X', generally east-west). These profiles (**Figures 5 and 6**) illustrate the major geologic units in a section view based on data collected during several phases of investigation.

Native subsurface soil deposits consist of a stratified sequence of outwash sand, peat, marine clay, and sand and gravel layers. Each of these layers is described below, beginning with the sandy fill layer, which is present at the ground surface, and progressing vertically downward to bedrock.

Sandy Fill. Sandy fill was encountered only at MW-405A, located between the two railroad tracks south of the Warehouse. The aerial extent of this fill appears to be confined to developed areas of the H&H site along the railroad tracks, and it is not present south of the railroad tracks.

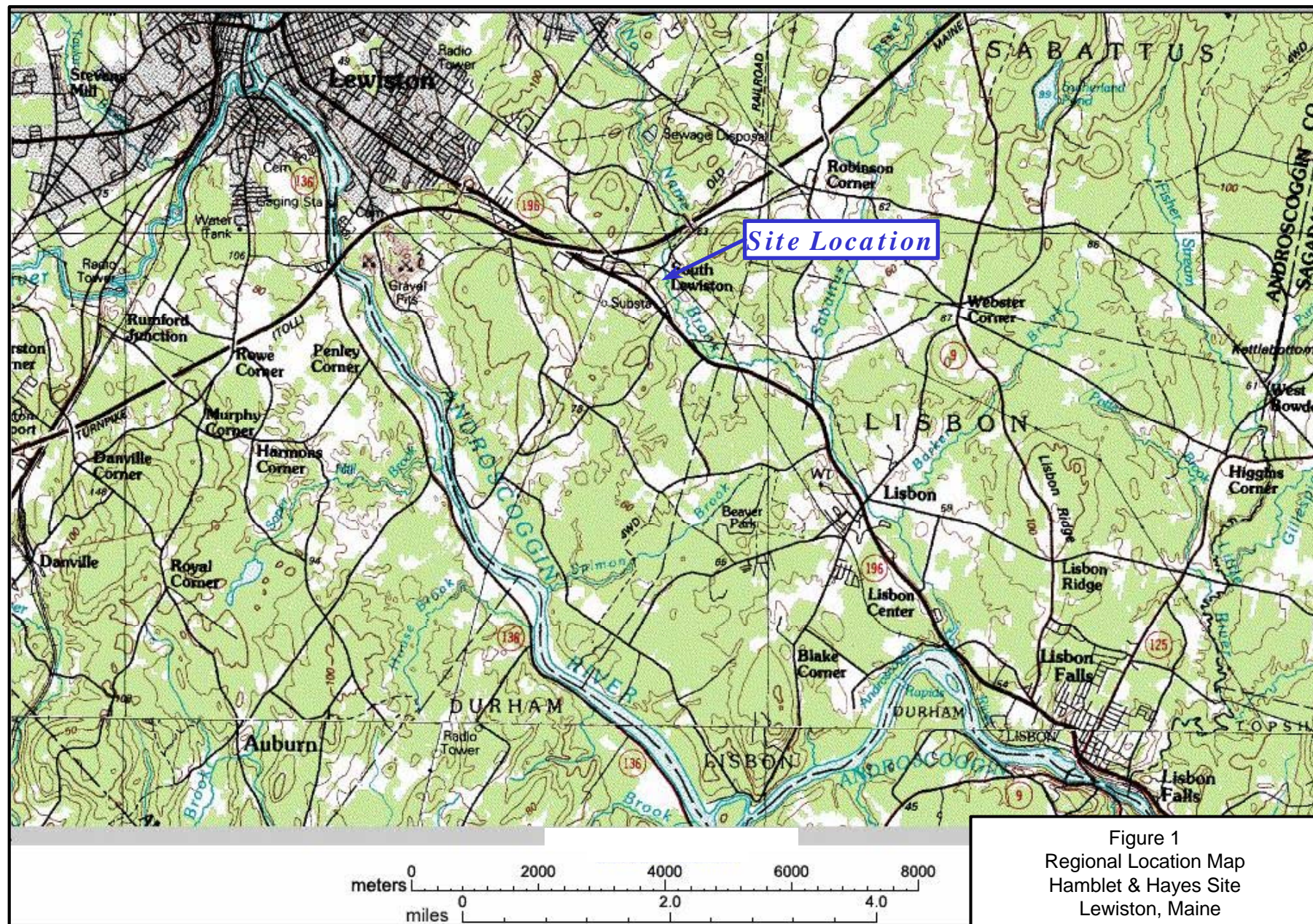
Silty Sand. Silty sand was encountered in all borings/wells installed, except MW-401B, TB-301, and hand auger locations in the center of the drainage course. This stratum varies in thickness from zero to 12 feet south of the Warehouse. This unit thins from west to east away from No Name Brook, and is absent at MW-401B near the drainage ditch that discharges to No Name Brook. Within the aerial extent of the delineated PCE contamination the silty sand overburden above the clay is approximately 4 feet thick.

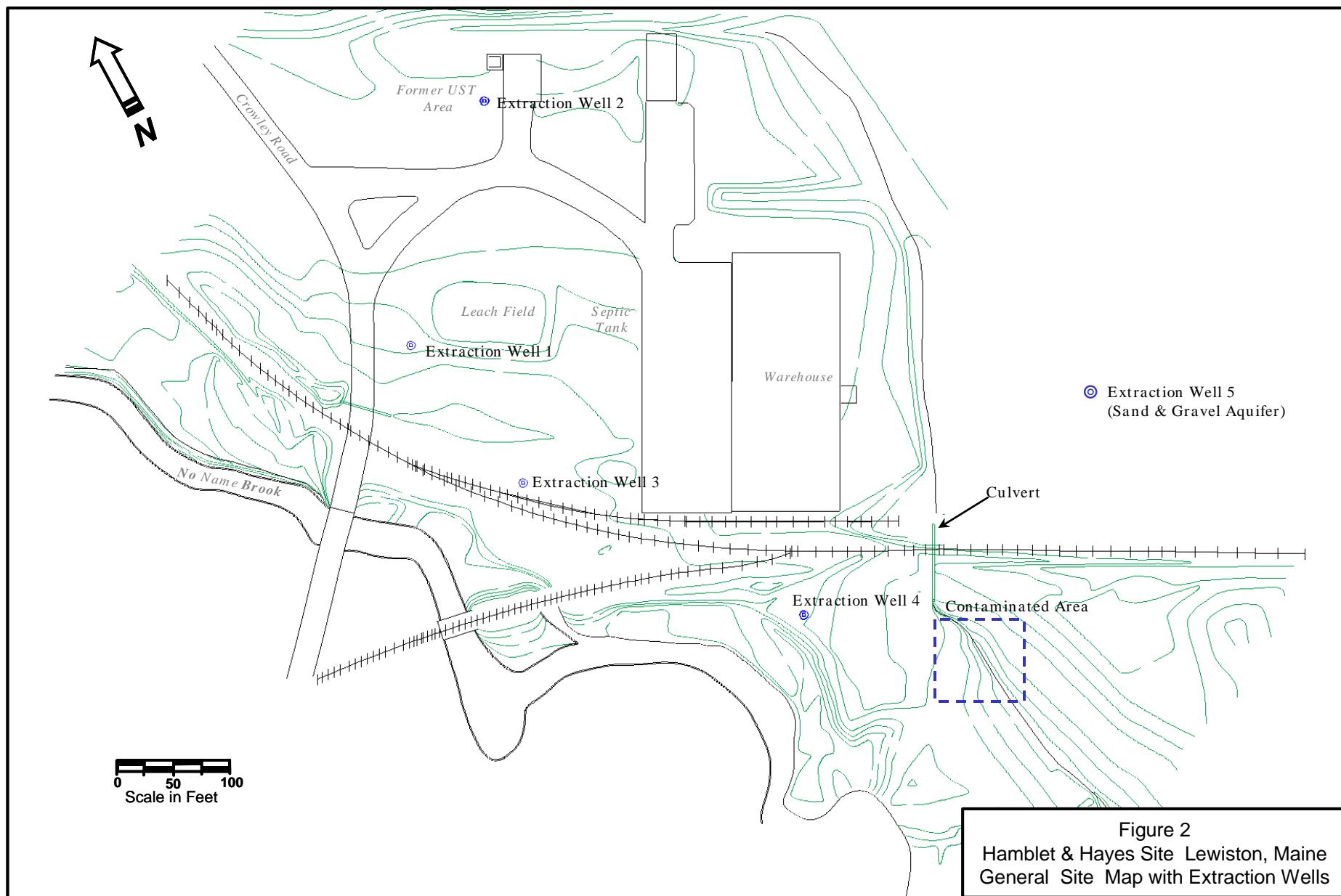
Marine Clay. Marine clay encountered is interpreted to be part of the Presumpscot Formation (Bloom, 1960). South of the Warehouse, the observed thickness ranges from 42 feet at MW-405A to 2 feet at MW-406. The depth to the top of the marine clay ranges from zero to 22 feet below ground surface (bgs). The upper and lower extents of the marine clay are interpreted from surfaces created by triangulation of interface points identified when classifying soils during advancement of investigative borings. **Figure 5 and Figure 6** are section views of the north-south, and west-east slices identified in **Figure 4**. As with the silty sand unit, the marine clay thins from north to south. The clay is approximately 20 to 22 feet thick in the location where the highest PCE levels were measured.

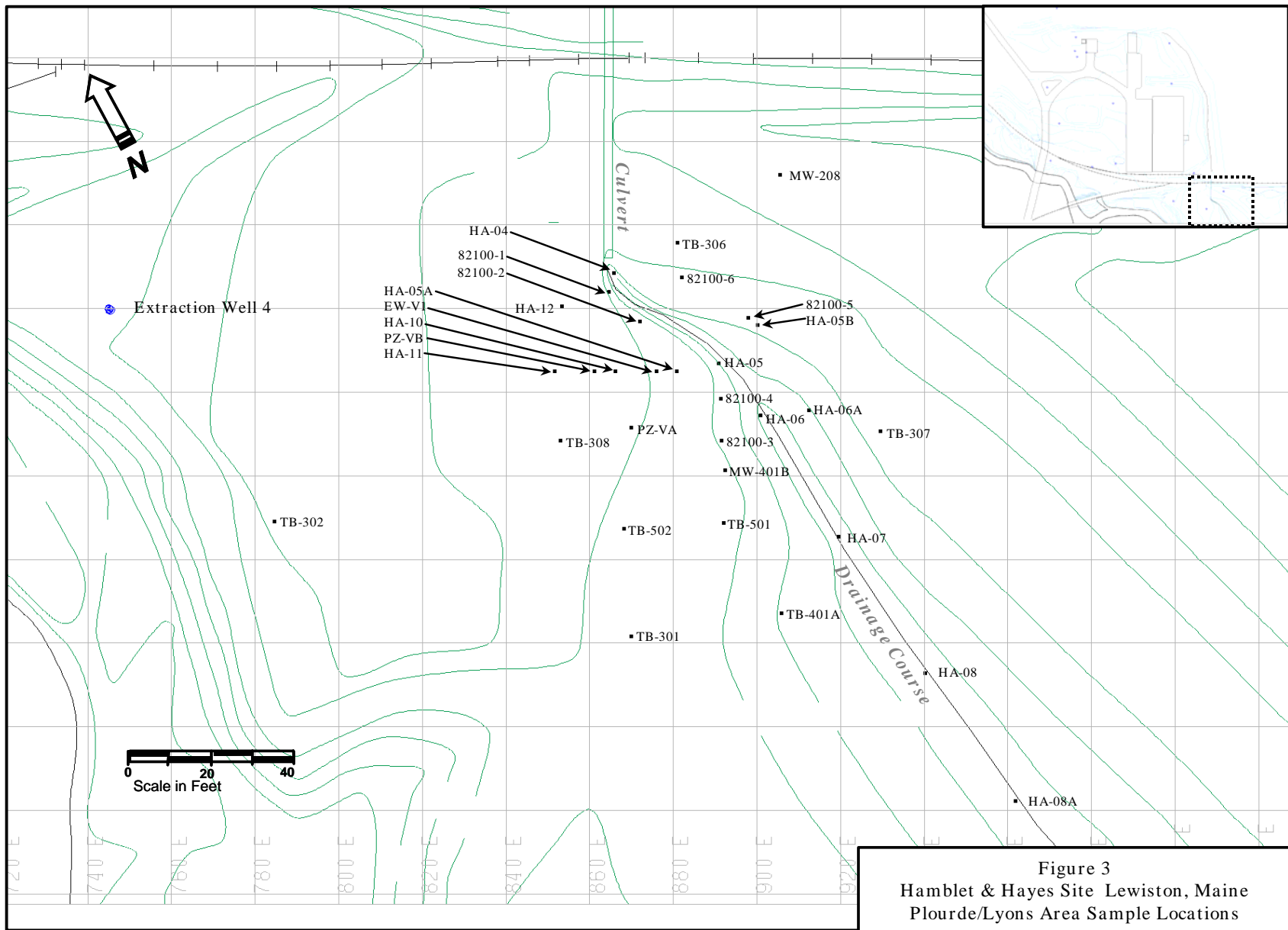
Sand and Gravel. The sand and gravel aquifer was encountered in all explorations that extended beneath the marine clay. This unit consists of material ranging from a well-graded fine sand to coarse gravel with cobbles, to a uniformly graded medium or coarse sand with nearly no silts/clays under the area south of the Warehouse. The observed depth to the top of the sand and

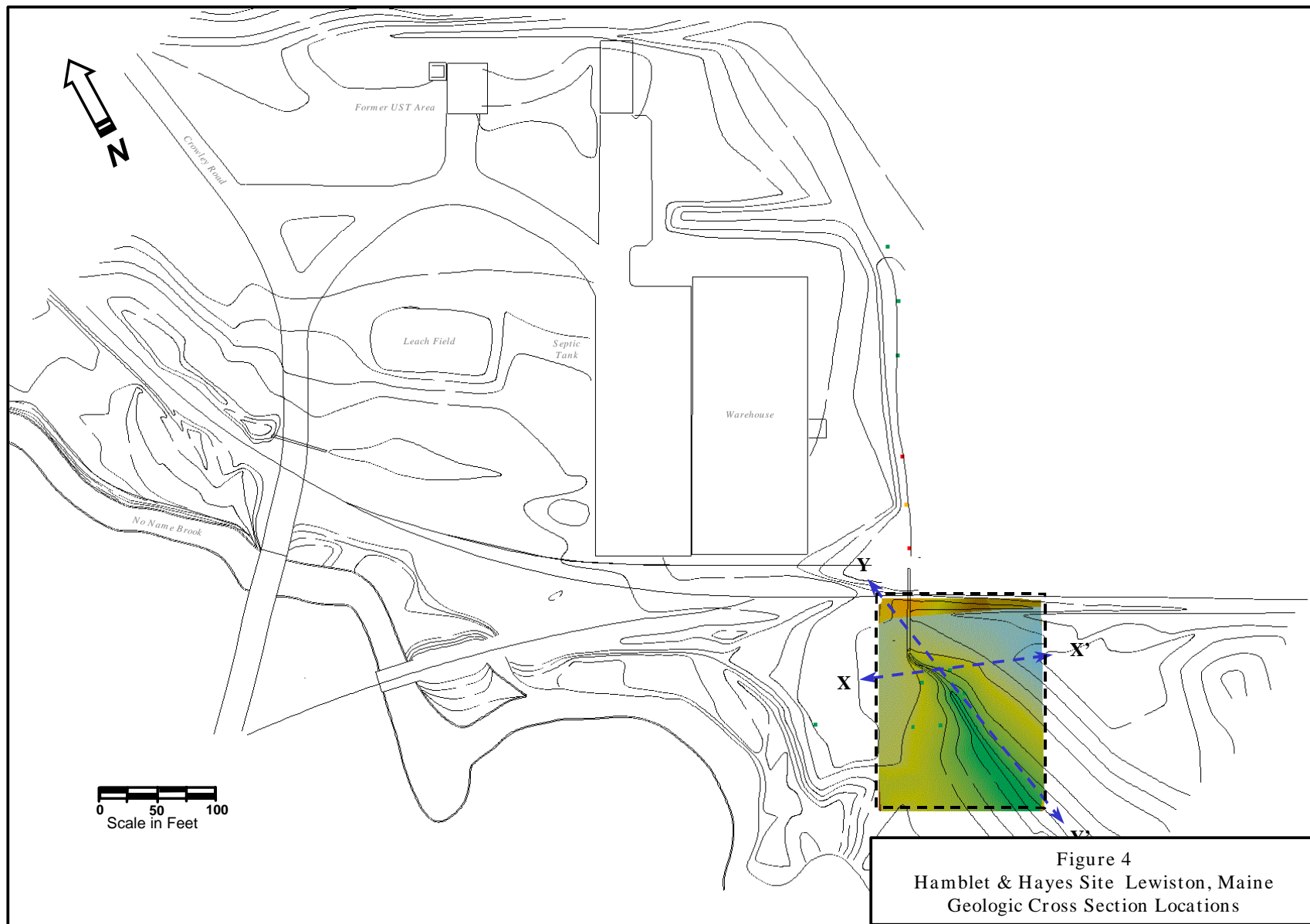
gravel south of the Warehouse ranges from six feet bgs at MW-406A to 53 feet bgs at MW-405A. The observed thickness of the sand and gravel unit varies from 2 feet at TB-403 to 36 feet at MW-406A. Supplemental hand auger sampling in the trench area in 1998 and 1999 was limited to shallow depths, but the top of the sand and gravel beneath the marine clay was encountered at a depth of 8 feet bgs at location MA-08A, further indicating that the clay thins out a few hundred feet to the south of the contaminated area. Test borings 501 and 502 installed during a high vacuum pilot test were also advanced to the top of the sand and gravel to delineate the thickness of the clay beneath the area of contamination.

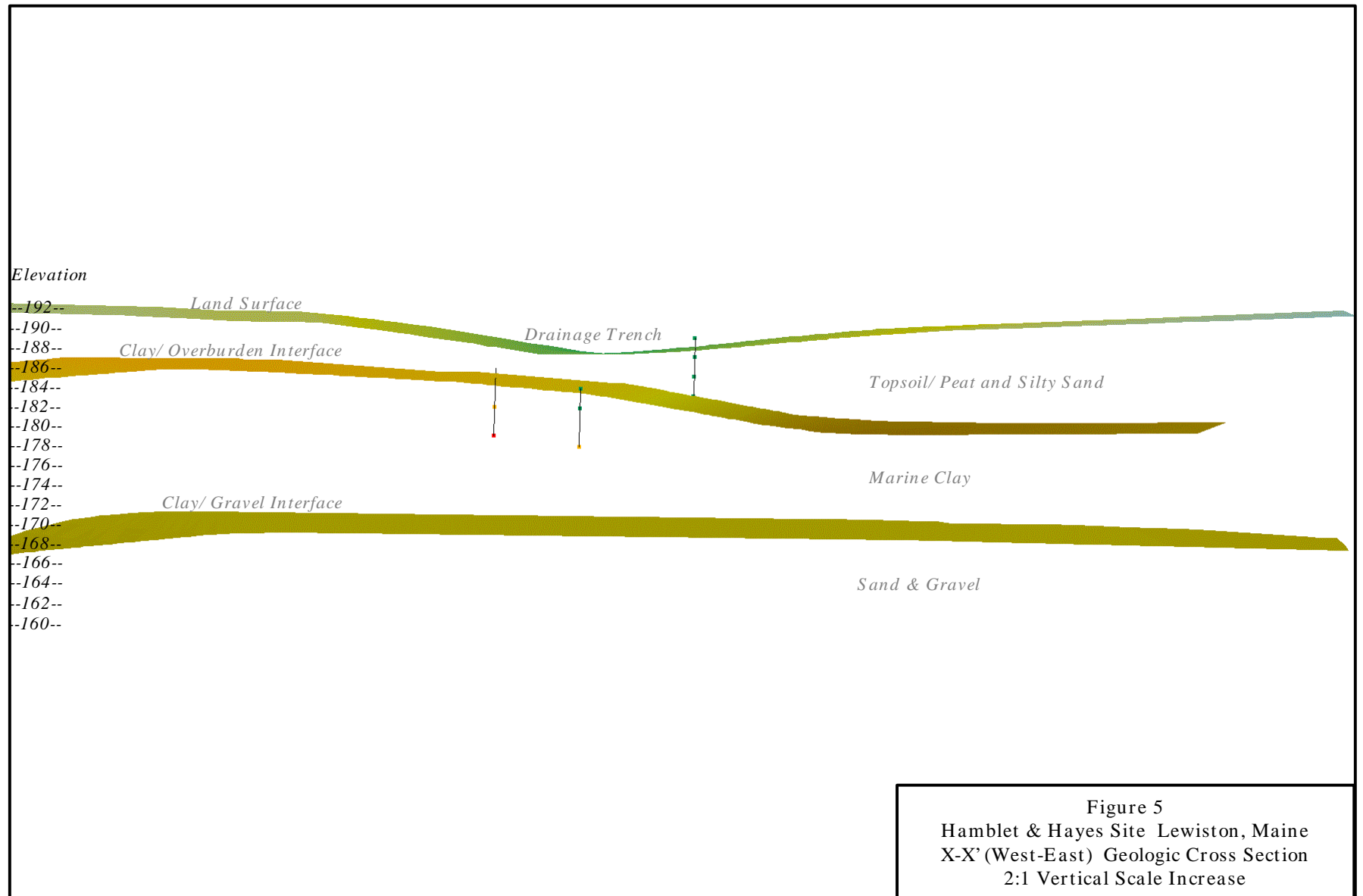
Bedrock. Bedrock was encountered at depths ranging from 26 to 73 feet bgs in subsurface explorations. A seismic survey was performed south of the Warehouse area and confirmed the presence of bedrock ranging from approximately 26 to 70 feet bgs. The bedrock in the area is of the Sangerville Formation.

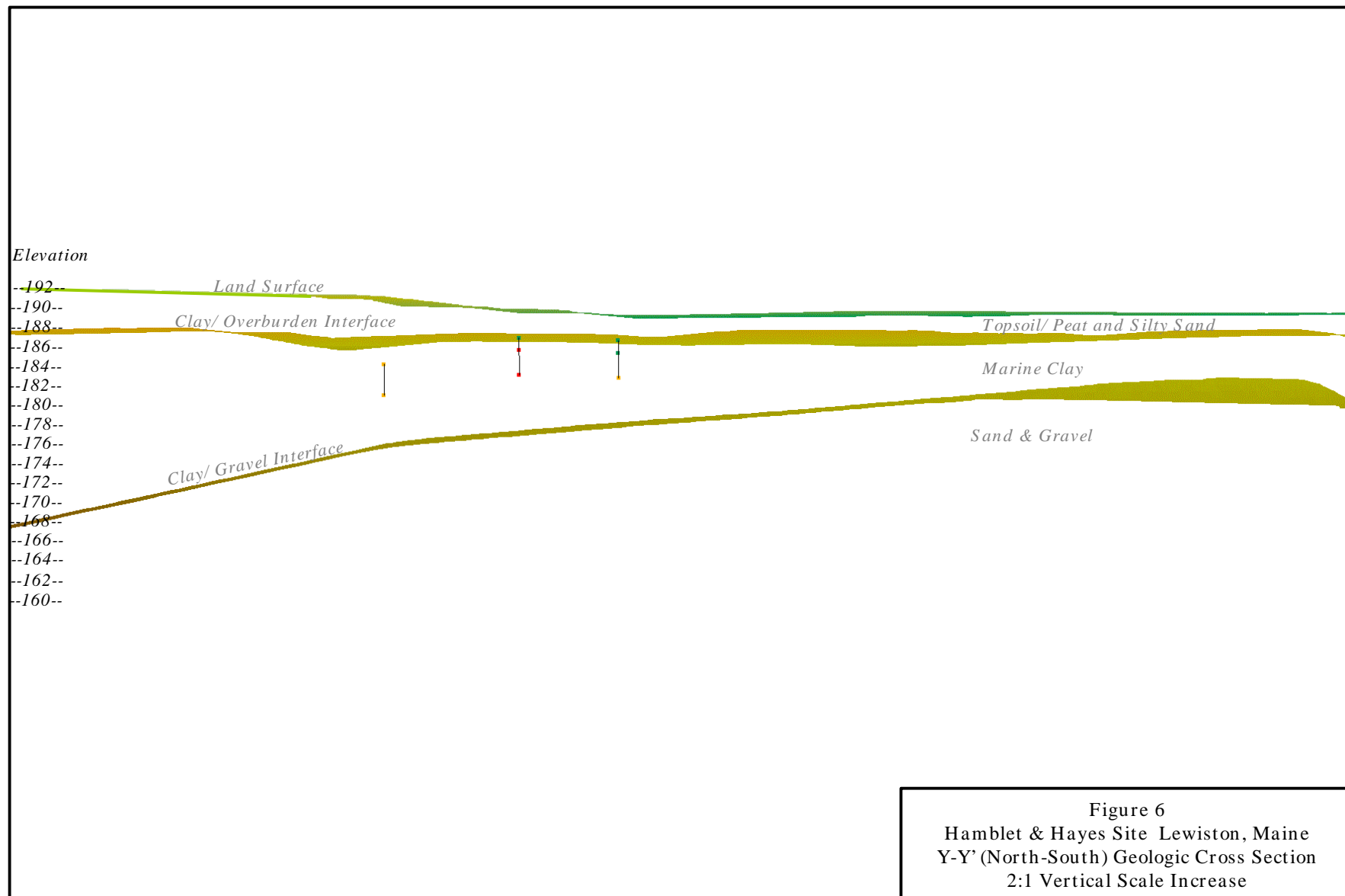












2.2 Hydrogeology

The groundwater table occurs in the silty sand with depths to water ranging from near the ground surface to approximately three feet bgs. The saturated thickness of the silty sand in the area south of the Warehouse ranges from zero near the drainage ditch to approximately seven feet near MW-405A. This relatively thin saturated thickness produces a vertically thin upper aquifer.

Piezometers and monitoring wells were used to develop and evaluate groundwater piezometric surface contours. Based on groundwater elevation readings recorded on July 24, 1996 during non-pumping conditions, shallow groundwater flow was determined to be west (toward No Name Brook). Based on available data, groundwater in the silty sand aquifer south of the Warehouse is believed to discharge into No Name Brook.

The saturated marine clay unit underlies the silty sand aquifer. The vertical hydraulic gradients observed between the silty sand and the sand and gravel aquifers indicate variability across the entire H&H Site, but appear to be generally upward south of the Warehouse. A triaxial, soft-walled permeability analysis was performed on an undisturbed sample of the marine clay during the SI program to evaluate the hydraulic conductivity of the clay. The sample was obtained during the drilling of MW-208, located west of the Warehouse, from 16 to 18 feet bgs. The reported hydraulic conductivity was 4.2×10^{-8} centimeters per second (cm/sec) (ABB-ES, 1992). This very low hydraulic conductivity value, combined with the generally upward hydraulic gradients, suggests that the marine clay is an effective barrier to the vertical migration of groundwater.

The sand and gravel aquifer encountered under the southern portion of the H&H Site is interpreted to be a part of a significant sand and gravel aquifer according to the Maine Geological Survey (ABB-ES, 1992). This aquifer extends south of the Site for approximately three miles. The groundwater flow direction in the sand and gravel aquifer south of the Warehouse is interpreted to be toward the east-southeast.

2.3 Assessment of Soil Contamination

During Phases III and IV of the SI, soil samples were collected during the advancement of subsurface explorations in the Plourde/Lyons area. No soil samples from the Plourde/Lyons area were collected during Phase I or Phase II of the SI.

Phase III sampling consisted of collecting soil samples for analysis of volatile organic compounds (VOCs) by U.S. Environmental Protection Agency (USEPA) Method 8240. Soil samples were collected during boring advancement and analyzed at an off-site laboratory. Samples collected during Phase III indicated the presence of tetrachloroethene (PCE) at locations TB-304, TB-306, and TB-308 at depths from 4 feet to 12 feet bgs.

Phase IV sampling consisted of collecting soil samples from subsurface explorations for analysis by field gas chromatography (GC) using purge and trap analysis. Results of GC analysis indicated the presence of PCE and four other chlorinated solvents: 1,1-dichloroethane (DCA), 1,1,1-trichloroethane (TCA), trichloroethene (TCE), and methylene chloride. These compounds were detected predominantly at depths from zero to 12 feet bgs. Additional samples were collected from selected subsurface explorations for analysis of VOCs by USEPA Method 8240 at an off-site laboratory. Samples collected during Phase IV indicated the presence of trans-1,2-dichloroethene (DCE), in addition to TCE and PCE, at depths from 4 feet to 12 feet bgs.

Field GC results at MW-401B (TCE at 680 micrograms per kilogram [$\mu\text{g/kg}$], PCE at 2,300 $\mu\text{g/kg}$) and at TB-401A (methylene chloride at 280 $\mu\text{g/kg}$, and TCA at 350 $\mu\text{g/kg}$) were the only detections of constituents in surface soils (0-2 feet bgs).

From 1998 through 2000 additional samples were collected to determine the extent of the contamination in this area and define the upper and lower surfaces of the marine clay. Hand auger sampling was conducted at several locations in and around the drainage course, followed by geoprobe sampling on two separate occasions in July and August of 2000. Soil data was also collected during the installation of a pilot scale high vacuum extraction system in 1999. One hundred and five (105) additional samples were collected in the Plourde/Lyons Area from 1998 through 2000 to better define the aerial and vertical extents of the contamination. These consisted of field screening for contamination using a photoionization detector and confirmatory analytical samples.

Sample locations in the Plourde/Lyons Area are indicated in **Figure 3**. Analytical data for the soil samples collected in the Plourde/Lyons area is summarized in **Table 1**. Table 1 includes both field screening and confirmatory analysis results.

PCE was the compound most frequently detected in soil samples and appears to be the compound that indicates the southernmost extent of site-related

constituents. Analytical results indicate that constituents detected in the former Plourde/Lyons area are concentrated in the vicinity of the drainage ditch that runs from north to south through the area. VOCs were detected within the 3 to 4-foot-thick saturated zone of the silty sand and extended roughly into the top 15 feet of the marine clay where the clay thickness is approximately 20 to 25 feet. Sampling conducted in 1998 through 2000 indicate that the PCE contamination does not originate from the main site as originally thought, but instead comes from a source deposited in the drainage course proximate to HA-05, located approximately 50 feet south of the culvert.

Analysis of the soil data were used to delineate the aerial extent of soil contamination is as shown in **Figure 7**. Vertically, soil contamination in this area extends roughly 12-15 feet bgs. Because groundwater at the Site is shallow (0-3 feet bgs), nearly all of the contaminated soil is in the saturated zone. There is approximately 12 feet of clay beneath the PCE contamination that has not been impacted through vertical migration. The thick clay layer of very low permeability clay is an effective barrier to water flow. However, this clay may not be as effective at preventing vertical migration of any PCE DNAPL.

Figures 8, 9, 10 and 11 show the approximate extent of PCE in the clay in four cross section views. The figures show field screening sample data in a qualitative manner from the soil borings to indicate the extent of the contamination. Field screening data is shown in these figures because there are significantly more data points than there are for confirmatory analyses. The number of clean sampled collected beneath the contaminated zone show that there is clean competent clay beneath the contaminated zone.

The interface between the bottom of the marine clay and the top of the sand & gravel aquifer is shown in the figures to show the depth of clay that has not been impacted with site contamination (the clean clay that protects the underlying sand and gravel aquifer). Sufficient data was collected to delineate approximately 6 to 10 feet of clean competent clay beneath the contaminated zone.

Table 1
Soil Sampling Results for the Plourde/Lyons Area (mg/kg)

Location	Depth (ft)	1,1,1-TCA	TCE	PCE	Benzene	Toluene	Xylene	1,1-DCE	1,1-DCA	1,1,2,2-TCA	TVOC
TB-301	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-301	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-301	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-301	27	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-301	37	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-302	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-302	13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-302	29	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-306	5	ND	ND	6.3	ND	ND	ND	ND	ND	ND	6.3
TB-306	9	ND	ND	11	ND	ND	ND	ND	ND	ND	11
TB-306	11	ND	ND	880	ND	ND	ND	ND	ND	ND	880
TB-307	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-307	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-307	19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TB-308	7	ND	ND	28	ND	ND	ND	ND	ND	ND	28
TB-308	9	ND	ND	23	ND	ND	ND	ND	ND	ND	23
TB-308	19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
82100-1	8	ND	ND	81.2	ND	ND	ND	ND	ND	ND	81.2
82100-1	16	ND	ND	0.28	ND	ND	ND	ND	ND	ND	0.28
82100-1	26	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
82100-2	8	ND	ND	74.6	ND	ND	ND	ND	ND	ND	74.6
82100-2	12	ND	ND	39.5	ND	ND	ND	ND	ND	ND	39.5
82100-3	8	ND	ND	42.3	ND	ND	ND	ND	ND	ND	42.3
82100-4	7	ND	ND	43.3	ND	ND	ND	ND	ND	ND	43.3
82100-4	11	ND	ND	408	ND	ND	ND	ND	ND	ND	408
82100-5	12	ND	ND	1963	ND	ND	ND	ND	ND	ND	1963
82100-5	15	ND	ND	4.95	ND	ND	ND	ND	ND	ND	4.95
82100-6	11	ND	ND	38.1	ND	ND	ND	ND	ND	ND	38.1
82100-6	16	ND	ND	63.4	ND	ND	ND	ND	ND	ND	63.4

Table 1 (Continued)

Soil Sampling Results for the Plourde/Lyons Area (mg/kg)

Location	Depth (ft)	1,1,1-TCA	TCE	PCE	Benzene	Toluene	Xylene	1,1-DCE	1,1-DCA	1,1,2,2-TCA	TVOC
EW-6v	1	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
EW-6v	4	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
EW-6v	7	ND	ND	15	ND	ND	ND	ND	ND	ND	15
EW-6v	9	ND	ND	34	ND	ND	ND	ND	ND	ND	34
EW-6v	11	ND	ND	19	ND	ND	ND	ND	ND	ND	19
EW-6v	17	ND	ND	0.11	ND	ND	ND	ND	ND	ND	0.11
HA-01	1	28	285	750	ND	ND	ND	ND	ND	ND	1063
HA-01	2	1.8	19	84	ND	ND	ND	ND	ND	ND	104.8
HA-01	5	1.8	24	130	ND	ND	ND	ND	ND	ND	155.8
HA-02	1	17	0.78	41	ND	ND	ND	ND	ND	ND	58.78
HA-02	3	3.8	3.8	780	ND	ND	ND	ND	ND	ND	787.6
HA-02	4	31	1.5	94	ND	ND	ND	ND	ND	ND	126.5
HA-02	6	79	1.1	90	ND	ND	ND	ND	ND	ND	170.1
HA-02	8	82	0.53	43	ND	ND	ND	ND	ND	ND	125.53
HA-02	10	67	0.26	37	ND	ND	ND	ND	ND	ND	104.26
HA-03	1	0.8	5.3	540	ND	ND	ND	ND	ND	ND	546.1
HA-03	2	1.6	9.1	410	ND	ND	ND	ND	ND	ND	420.7
HA-03	4	1.2	0.74	61	ND	ND	ND	ND	ND	ND	62.94
HA-03	6	4.8	2.9	430	ND	ND	ND	ND	ND	ND	437.7
HA-04	2.5	ND	ND	1.3	ND	ND	ND	ND	ND	ND	1.3
HA-04	4.5	ND	ND	150	ND	ND	ND	ND	ND	ND	150
HA-04	8.5	ND	ND	28	ND	ND	ND	ND	ND	ND	28
HA-05	2.5	ND	ND	2.7	ND	ND	ND	ND	ND	ND	2.7
HA-05	4.5	ND	ND	890	ND	ND	ND	ND	ND	ND	890
HA-05	8.5	ND	ND	1500	ND	ND	ND	ND	ND	ND	1500
HA-05A	2	ND	ND	29	ND	ND	ND	ND	ND	ND	29
HA-05A	3	ND	ND	110	ND	ND	ND	ND	ND	ND	110
HA-05A	4	ND	ND	4000	ND	ND	ND	ND	ND	ND	4000
HA-05A	6	ND	ND	41	ND	ND	ND	ND	ND	ND	41
HA-05A	7	ND	ND	4000	ND	ND	ND	ND	ND	ND	4000
HA-05A	8	ND	ND	10	ND	ND	ND	ND	ND	ND	10

Table 1 (Continued)

Soil Sampling Results for the Plourde/Lyons Area (mg/kg)

Location	Depth (ft)	1,1,1-TCA	TCE	PCE	Benzene	Toluene	Xylene	1,1-DCE	1,1-DCA	1,1,2,2-TCA	TVOC
HA-05B	1	ND	ND	0.55	ND	ND	ND	ND	ND	ND	0.55
HA-05B	3	ND	ND	13	ND	ND	ND	ND	ND	ND	13
HA-05B	5	ND	ND	27	ND	ND	ND	ND	ND	ND	27
HA-05B	7	ND	ND	50	ND	ND	ND	ND	ND	ND	50
HA-05B	9	ND	ND	41	ND	ND	ND	ND	ND	ND	41
HA-05B	11	ND	ND	41	ND	ND	ND	ND	ND	ND	41
HA-06	3	ND	ND	0.95	ND	ND	ND	ND	ND	ND	0.95
HA-06	5	ND	ND	8.1	ND	ND	ND	ND	ND	ND	8.1
HA-06	9	ND	ND	61	ND	ND	ND	ND	ND	ND	61
HA-07	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-07	6	0.65	ND	0.17	ND	ND	ND	ND	ND	ND	0.82
HA-07	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-08	3	200	ND	ND	ND	ND	ND	ND	ND	ND	200
HA-08	5	500	ND	ND	ND	ND	ND	ND	ND	ND	500
HA-08	8	110	ND	ND	ND	ND	ND	ND	ND	ND	110
HA-08A	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-08A	6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-08A	8	0.11	ND	ND	ND	ND	ND	ND	ND	ND	0.11
HA-10	3	ND	ND	600	ND	ND	ND	ND	ND	ND	600
HA-10	5	ND	ND	110	ND	ND	ND	ND	ND	ND	110
HA-10	7	ND	ND	1300	ND	ND	ND	ND	ND	ND	1300
HA-10	9	ND	ND	4100	ND	ND	ND	ND	ND	ND	4100
HA-10	10	ND	ND	10	ND	ND	ND	ND	ND	ND	10
HA-15	2	0.75	ND	4.8	ND	ND	ND	ND	ND	ND	5.55
HA-15	4	28	ND	25	ND	ND	ND	ND	ND	ND	53
HA-15	9	100	ND	78	ND	ND	ND	ND	ND	ND	178
HA-15	10	100	ND	66	ND	ND	ND	ND	ND	ND	166
HA-15	12	28	ND	530	ND	ND	ND	ND	ND	ND	558
HA-16	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-16	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-16	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HA-17	3	0.42	ND	1.8	ND	ND	ND	ND	ND	ND	2.22
HA-17	5	2.6	ND	4.4	ND	ND	ND	ND	ND	ND	7
HA-17	8	1.8	ND	6.3	ND	ND	ND	ND	ND	ND	8.1

Table 1 (Continued)

Soil Sampling Results for the Plourde/Lyons Area (mg/kg)

Location	Depth (ft)	1,1,1-TCA	TCE	PCE	Benzene	Toluene	Xylene	1,1-DCE	1,1-DCA	1,1,2,2-TCA	TVOC
HA98-11	2	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-11	6	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-11	8	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-12	2	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-12	4	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-12	6	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-12	8	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-6A	1	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-6A	2	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-6A	3	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
HA98-6A	5	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
MW-208	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-208	15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-401B	1	ND	0.68	2.3	ND	ND	ND	ND	ND	ND	2.98
MW-401B	3	0.056	ND	0.63	ND	ND	ND	ND	ND	ND	0.686
MW-401B	5	0.12	ND	1.6	ND	ND	ND	ND	ND	ND	1.72
MW-401B	7	0.13	ND	0.4	ND	ND	ND	ND	ND	ND	0.53
MW-401B	9	ND	ND	22	ND	ND	ND	ND	ND	ND	22
MW-401B	11	ND	ND	1.6	ND	ND	ND	ND	ND	ND	1.6
PZ-VA	1	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
PZ-VA	3	ND	ND	1.6	ND	ND	ND	ND	ND	ND	1.6
PZ-VA	5	ND	ND	18	ND	ND	ND	ND	ND	ND	18
PZ-VA	7	ND	ND	672	ND	ND	ND	ND	ND	ND	672
PZ-VA	9	ND	ND	2.1	ND	ND	ND	ND	ND	ND	2.1
PZ-VA	11	ND	ND	0.16	ND	ND	ND	ND	ND	ND	0.16
PZ-VB	1	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
PZ-VB	6	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
PZ-VB	8	ND	ND	4.3	ND	ND	ND	ND	ND	ND	4.3
PZ-VB	10	ND	ND	12	ND	ND	ND	ND	ND	ND	12
PZ-VB	17	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01

Table 1 (Continued)

Soil Sampling Results for the Plourde/Lyons Area (mg/kg)

Location	Depth (ft)	1,1,1-TCA	TCE	PCE	Benzene	Toluene	Xylene	1,1-DCE	1,1-DCA	1,1,2,2-TCA	TVOC
TB-401A	1	0.35	ND	ND	ND	ND	ND	ND	ND	ND	0.35
TB-401A	3	0.07	ND	0.04	ND	ND	ND	ND	ND	ND	0.11
TB-401A	5	0.83	ND	0.11	ND	ND	ND	ND	ND	ND	0.94
TB-401A	7	1.1	ND	0.011	ND	ND	ND	ND	ND	ND	1.111
TB-401A	9	0.043	ND	ND	ND	ND	ND	ND	ND	ND	0.043
TB-501	2	ND	ND	0.00001	ND	ND	ND	ND	ND	ND	0.00001
TB-501	12	ND	ND	0.0006	ND	ND	ND	ND	ND	ND	0.0006
TB-501	18	ND	ND	0.00001	ND	ND	ND	ND	ND	ND	0.00001
TB-502	2	ND	ND	0.00001	ND	ND	ND	ND	ND	ND	0.00001
TB-502	16	ND	ND	0.0008	ND	ND	ND	ND	ND	ND	0.0008
TB-502	6	ND	ND	0.005	ND	ND	ND	ND	ND	ND	0.005
TB-502	8	ND	ND	0.005	ND	ND	ND	ND	ND	ND	0.005
TB-502	10	ND	ND	0.01	ND	ND	ND	ND	ND	ND	0.01
TB-502	15	ND	ND	0.0002	ND	ND	ND	ND	ND	ND	0.0002

2.4 Ongoing Groundwater Remedial Activities

Ciba is currently performing remedial actions to address constituents in both the shallow and deep groundwater aquifers. A groundwater extraction and treatment system was constructed and began operation in October 1996. The system is currently extracting and treating contaminated groundwater from both aquifers.

The extraction system utilizes five extraction wells to extract contaminated groundwater. The treatment system removes VOCs from the extracted groundwater by air stripping. Off gases from the system are routed through a carbon adsorption system to remove and collect the contaminants for off-site disposal. Treated water is discharged to the Lewiston-Auburn Water Pollution Control Authority publicly owned treatment works for treatment and discharge.

Four of the extraction wells (**Figure 12**) are used to extract groundwater from the shallow silty sand aquifer at the maximum rate possible, as determined by the recovery rate of each individual well. The shallow wells pump intermittently based on individual recovery. The fifth extraction well (**Figure 13**) extracts groundwater from the deep sand and gravel aquifer at the Site at a rate of approximately 11 gallons per minute.

In addition to groundwater extraction and treatment, Ciba conducts groundwater quality and water level monitoring to evaluate the groundwater extraction system capture zones. The wells used in the groundwater monitoring program are included in **Figure 12** and **Figure 13**. Groundwater quality monitoring is conducted on a semi-annual basis; water level monitoring is conducted quarterly. Results of the monitoring program are evaluated and submitted to the MEDEP annually in accordance with the Compliance Order for the Site.

Quarterly groundwater elevations from 2000 were used to determine the radius of influence for the extraction wells for both the shallow aquifer and the sand and gravel aquifer that are shown in **Figure 12** and **Figure 13**.

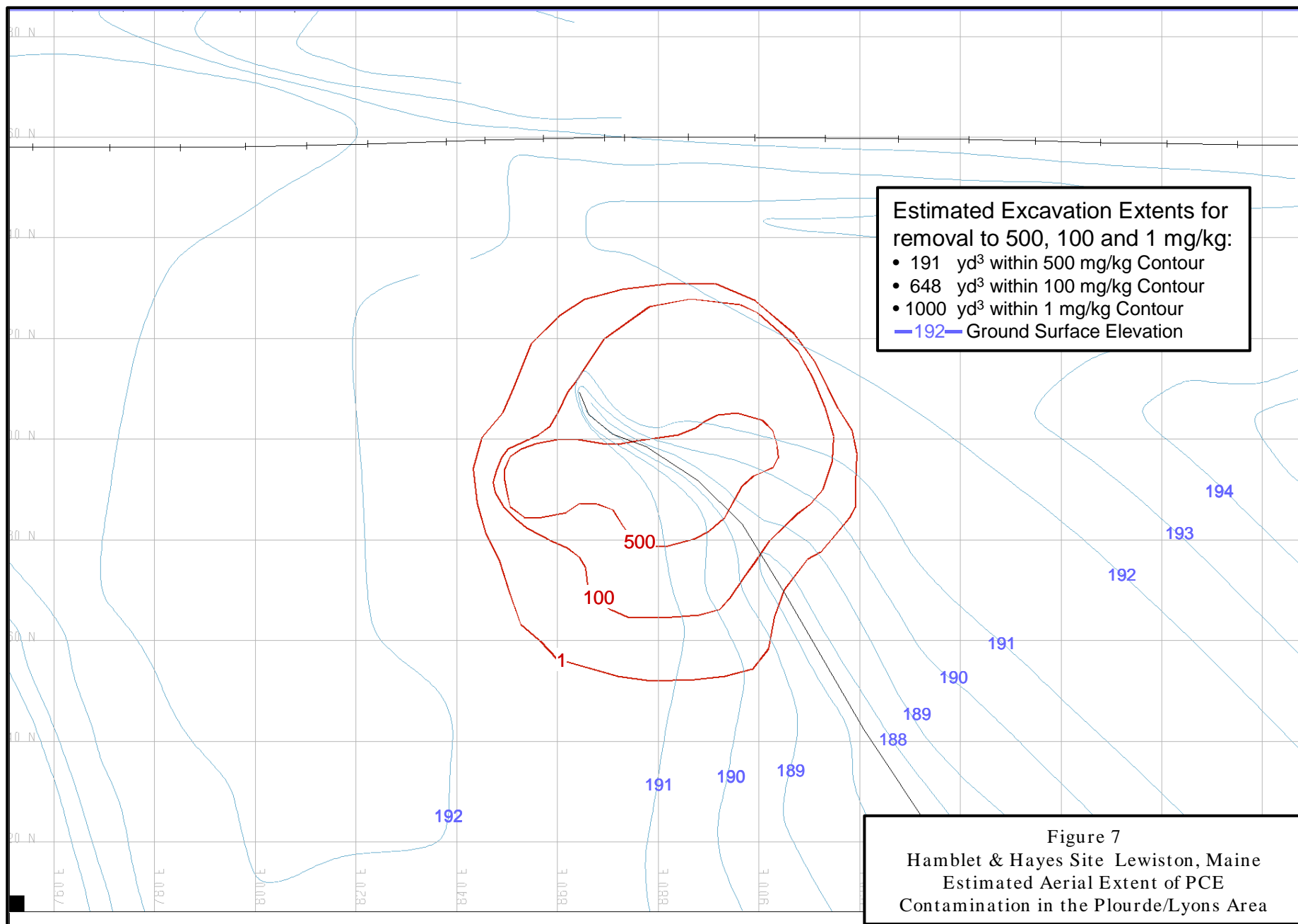
Based on monitoring results from the deeper sand and gravel aquifer, this aquifer appears to be protected by the marine clay layer which underlies the shallow contamination at the Site. As operation of the system continues, monitoring data will be evaluated on an annual basis to refine the actual capture zone boundaries, and monitor contaminant concentrations in both the shallow and deep aquifers to assess any visible trends in concentrations.

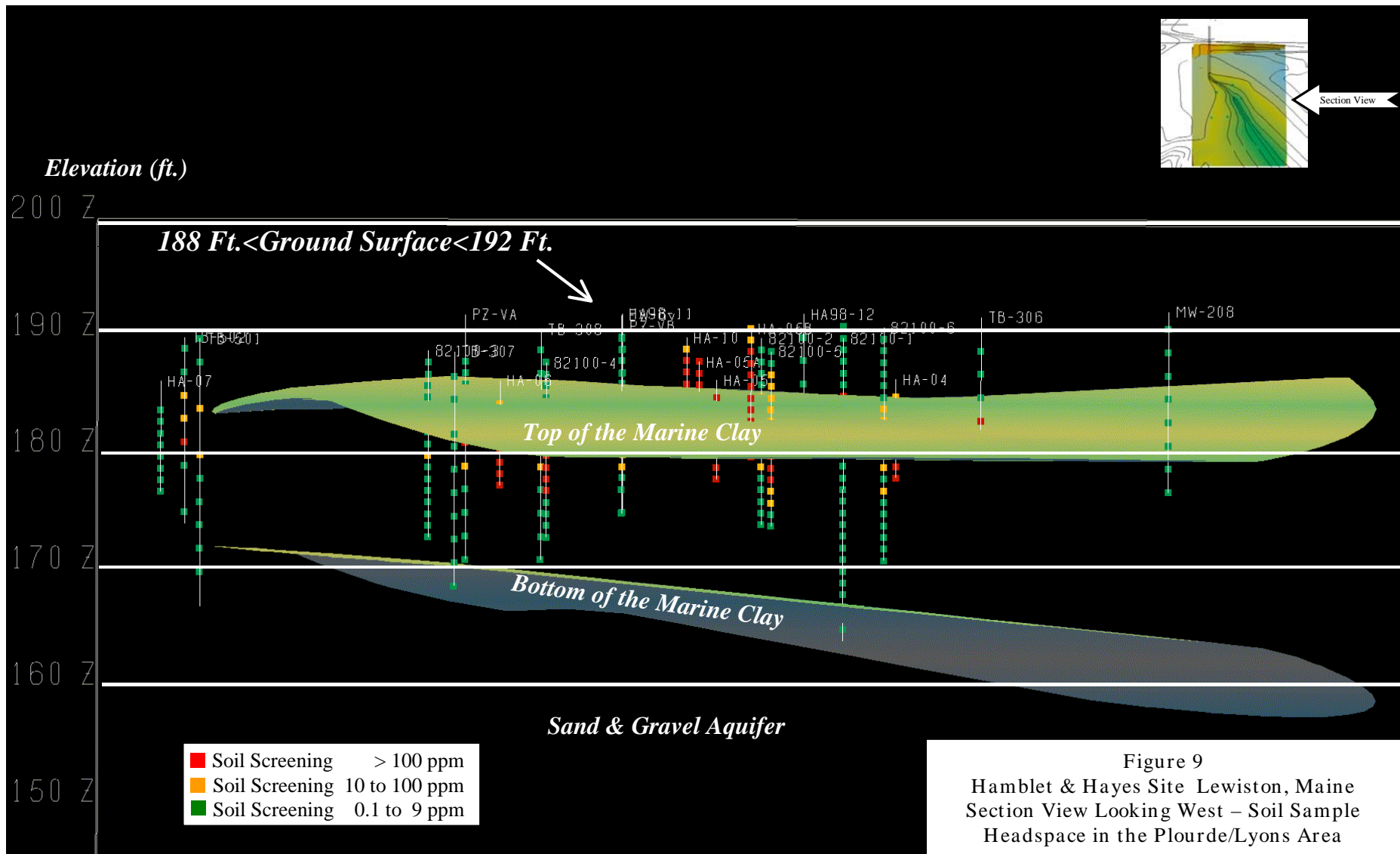
Because of the existing groundwater extraction and treatment system, ongoing groundwater monitoring program, thin saturated thickness of the silty sand, and minimal groundwater flow in the area, alternatives addressing groundwater remediation will not be included in this evaluation of alternatives. Groundwater monitoring, coupled with optimization of the groundwater extraction system, will be used to address groundwater in the area. Therefore, groundwater will not be addressed as a media of concern in this RAE. Alternatives included in this evaluation will be focused on addressing soil contamination, its potential risks to human and ecological receptors, and its potential impact on groundwater quality in the sand and gravel aquifer.

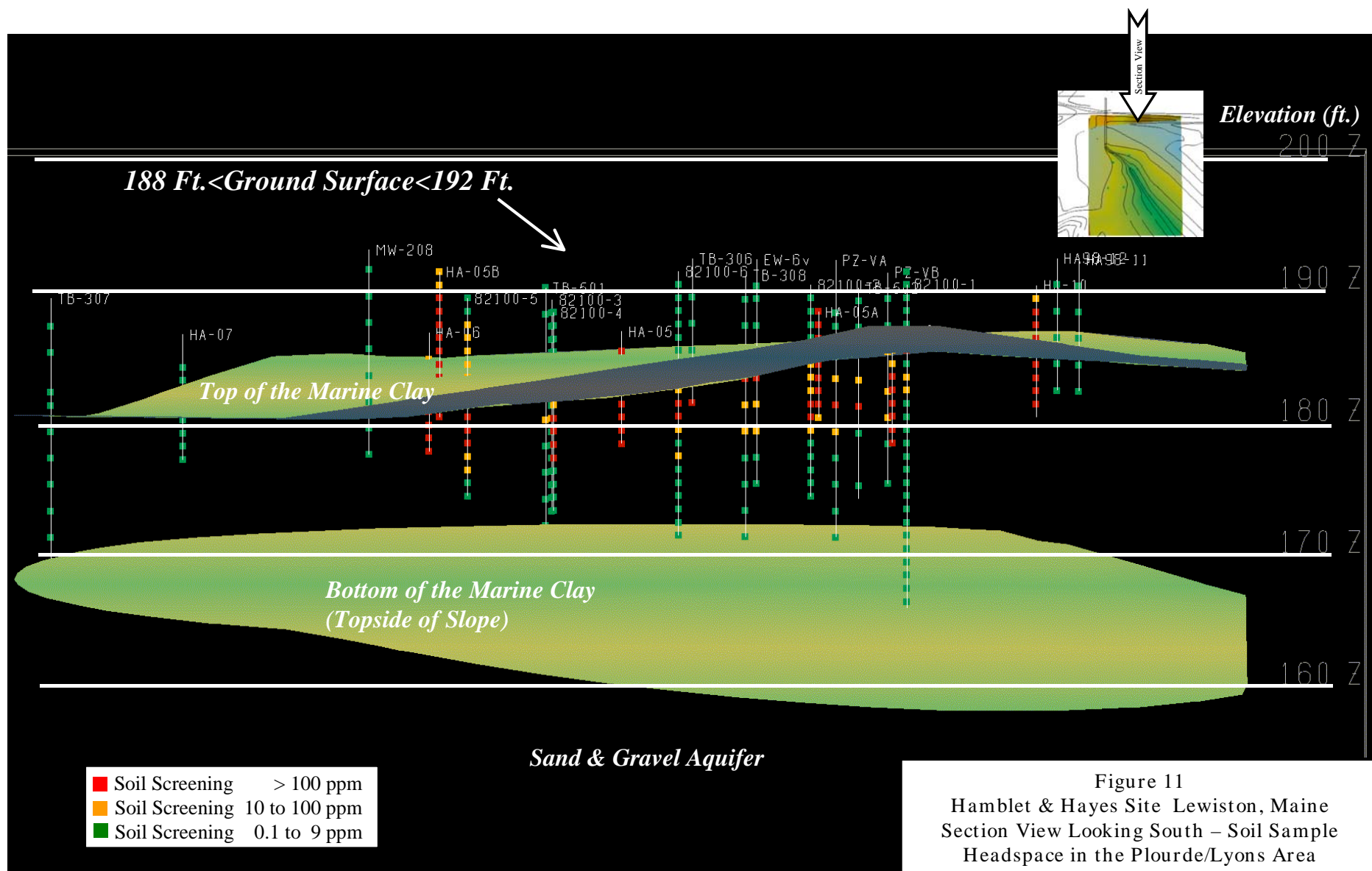
2.5 Regulatory Status

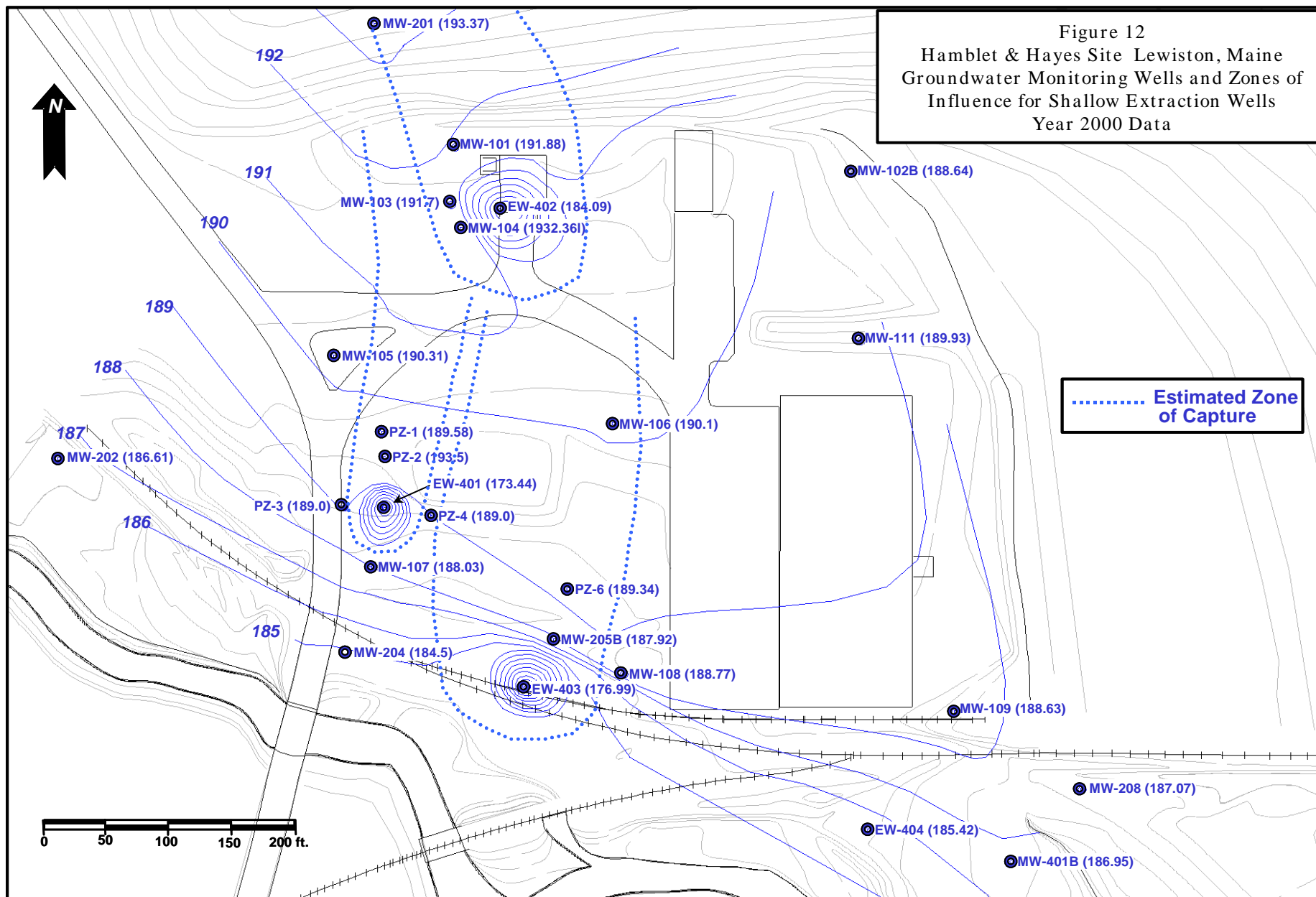
The remedial activities at the H&H Site are being conducted under a Compliance Order issued by the MEDEP. Contaminated soil and groundwater at the Site are the result of former releases at the Site of materials listed under the MEDEP Hazardous Waste Regulations and Resource Conservation and Recovery Act (RCRA) as hazardous waste regulations. In accordance with these regulations, media contaminated with listed hazardous materials are required to be managed as a hazardous waste, and are, therefore, required to follow applicable permitting requirements.

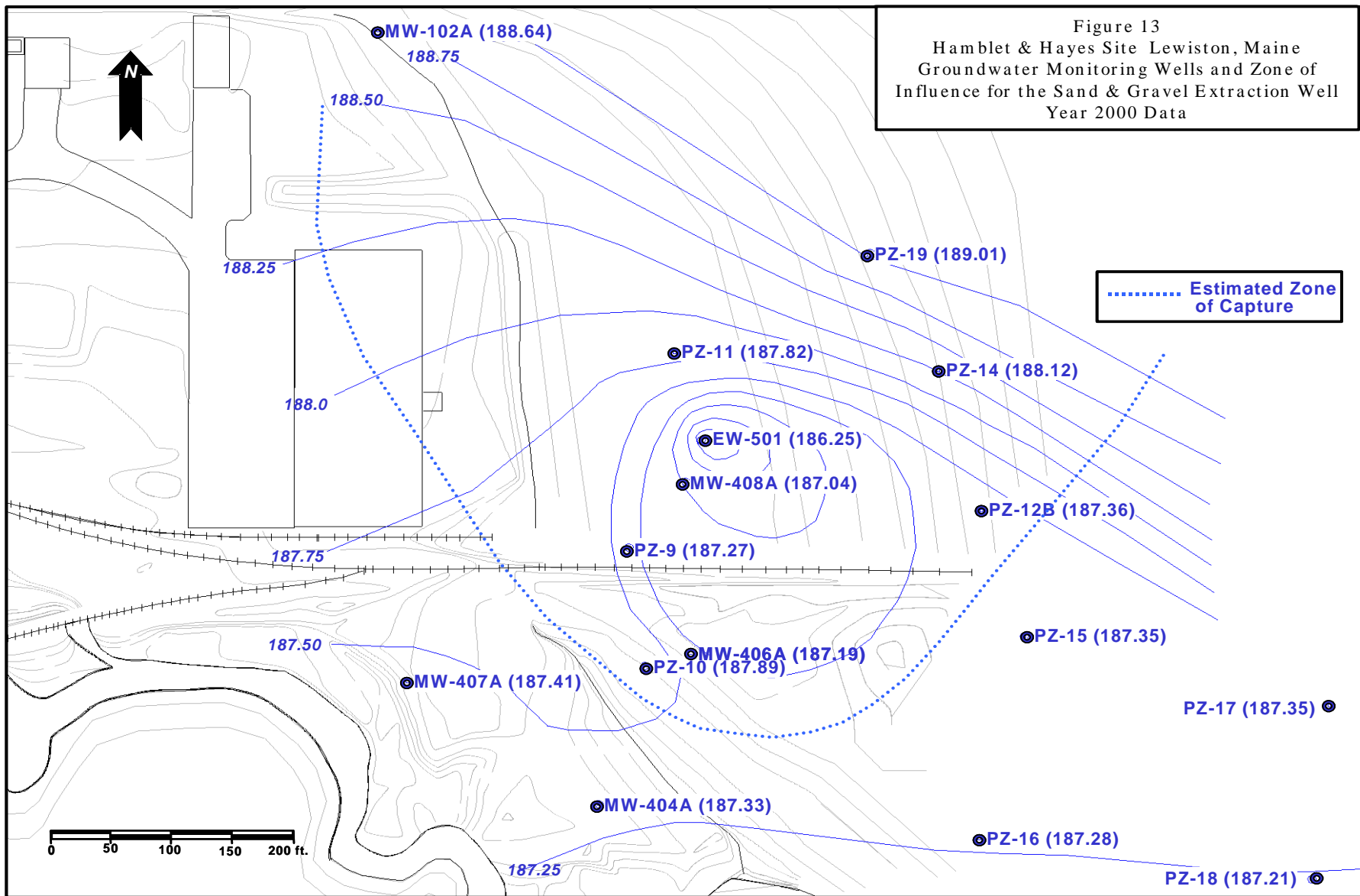
MEDEP policy is to waive RCRA permitting requirements for on-site treatment of wastes being conducted under a Remedial Action (MEDEP, 1997c). By waiving the permitting requirements, administrative delays associated with permitting can be avoided, and remedial actions can be conducted more efficiently under MEDEP oversight. Waiving of permitting requirements allows for on-site treatment alternatives, which may normally be screened out due to administrative infeasibility associated with permit filing, to be evaluated as potential remedial alternatives. Media contaminated with listed hazardous materials that are transported, treated, or disposed off-site would be required to be managed as a hazardous waste, and required to follow applicable permitting requirements.











3.0 CORRECTIVE ACTION OBJECTIVES

Corrective Action Objectives (CAOs) are goals developed to protect human health and the environment. CAOs are based on the following:

- contaminated media and the constituents of concern;
- potential migration pathways;
- potential exposure routes and receptors ;
- regulatory requirements and guidance;
- remediation standards

Development of CAOs for this RAE is presented in the following subsections.

3.1 Contaminated Media and Constituents of Concern

This RAE addresses contaminated soil at the former Plourde/Lyons area. Constituents were detected in soil during the SI activities. These constituents, identified as chlorinated solvents, primarily PCE, are present in soil from former releases at the H&H Site.

3.2 Potential Migration Pathways

Potential migration pathways for soil contaminants include volatilization of constituents to the atmosphere and/or soil gas, migration via surface runoff and migration via infiltration. Because Site constituents are predominantly at depths greater than 2 feet bgs, migration of constituents via volatilization to the atmosphere or by surface runoff are not considered to be potential migration pathways at the Site. Migration via volatilization to soil gas and via infiltration are considered to be potential migration pathways for Site-related constituents.

3.2.1 Potential Exposure Routes and Receptors

Potential exposure routes at the Site consist of direct exposure to contaminated surface soil by human and ecological receptors and exposure to contaminated subsurface soil by human receptors. Because there are no subsurface structures in the vicinity of the former Plourde/Lyons area, no potential for human exposure to soil gas exists. Potential impacts of contaminated soil on Site groundwater was also evaluated.

Remediation standards will be developed in **Section 3.5** using risk analysis and applicable regulatory guidance, and evaluating the potential impact to receptors for those constituents for which a complete exposure pathway exists.

Human Health Exposure to Surface Soil. The 1993 Human Health and Ecological Evaluation addressed this potential exposure pathway, and concluded concentration of Site constituents did not pose unacceptable risk at concentrations detected in surface soils (ABB-ES, 1993b and 1993c). Protection of human health from exposure to surface soils, therefore, will not be retained as a CAO.

Human Health Exposure to Subsurface Soil: This exposure scenario represents a potential exposure pathway. Protection of human health by preventing exposure to contaminated subsurface soil will be retained as a CAO, and remediation standards for use in the RAE will be developed in **Section 3.5** to address this potential exposure pathway.

Protection of Groundwater: The shallow aquifer pinches out at the ground surface in the former Plourde/Lyons area. The shallow groundwater extraction system capture zone was predicted to extend into the former Plourde/Lyons area of contamination where the shallow aquifer is present. To date, the deeper sand and gravel aquifer has been protected by the marine clay layer which underlies this area, as evidenced by water quality samples from down gradient sand and gravel aquifer monitoring wells. Continued operation of the deeper sand and gravel aquifer extraction well provides added protection from potential down gradient migration (see capture zone shown in **Figure 11**). CAOs developed for protection of groundwater will be focused on monitoring constituent concentrations in groundwater and minimizing potential impacts of contaminated soil on groundwater. Remediation standards for use in the RAE will be developed in **Section 3.5** for protection of groundwater.

Ecological Risk Evaluation. A supplementary ecological risk evaluation was conducted to determine whether exposure to surface or subsurface soil at the H&H Site could pose a threat to terrestrial receptors. As part of this evaluation, an assessment of ecological risks to terrestrial organisms exposed to VOCs in soil was conducted to determine whether protection of terrestrial organisms should be retained as a CAO. The primary routes of exposure evaluated for terrestrial organisms were ingestion and inhalation of VOCs from contaminated soil. Risks to wildlife were characterized using the hazard quotient (HQ) approach, by comparing modeled soil ingestion and inhalation doses to Reference Toxicity Values (RTVs) and calculating a HQ. Risks to invertebrates were qualitatively characterized by comparing toxicity benchmarks to surface soil exposure point concentrations. The evaluation is summarized in the following paragraphs. Potential ecological risks associated with other

environmental media at the Site have been previously evaluated (ABB-ES, 1993b,c).

Risks to Terrestrial Wildlife. Potential risks to wildlife from surface soil ingestion were estimated by dividing the estimated doses calculated for each constituent of potential concern by the most conservative chronic ingestion RTV. For a given contaminant of concern, an $HQ \leq 1$ indicates a level of no significant risk. As the magnitude of the HQ increases above 1, the likelihood of adverse ecological effects increases. The HQs for the selected wildlife receptors were three to four orders of magnitude below 1 for the contaminants of potential concern in surface soil. This suggests that concentrations of VOCs in surface soil are unlikely to adversely affect terrestrial wildlife that ingest contaminated soil.

The risk evaluation for inhalation exposures to burrowing wildlife resulted in a calculated HQ of 3.5. Potential risks were primarily from inhalation of PCE. However, the maximum detected PCE concentration in subsurface soil was used to model the burrow air concentrations, and the lowest chronic RTV was selected for comparison. Considering these conservative assumptions, risks from inhalation of PCE are likely to be negligible.

Risks to Soil Invertebrates. Potential risks to terrestrial invertebrates were estimated by comparing detected surface soil concentrations with the invertebrate RTV developed for acute effects (i.e., mortality). Concentrations of VOCs detected in surface soil ranged from 0.28 to 2.3 milligrams per kilogram (mg/kg), which are two to three orders of magnitude below the RTV (150 mg/kg). This suggests terrestrial invertebrates inhabiting surface soil at the former Plourde/Lyons area are not at risk from exposure to surface soil.

Based on the ecological risk evaluation, protection of ecological receptors will not be retained as a CAO. The ecological risk evaluation is included as **Attachment 1**.

CAOs retained for further consideration in the detailed evaluation include protection of human health by preventing exposure to contaminated subsurface soil, and protection of groundwater. Protection of groundwater will be focused on monitoring constituent concentrations in groundwater and minimizing potential impacts of contaminated soil on groundwater.

3.3 Regulatory Requirements and Guidelines

Remedial actions conducted at the Site must comply with local, state, and federal regulatory requirements. Additionally, local, state, and federal guidance can be used to guide and direct remedial actions conducted at the Site. As part

of this evaluation, a review of guidelines relevant to the remedial actions being conducted at the Site are presented in the following paragraphs.

Land Disposal Restrictions. Because contaminated soil at the Site is classified as RCRA hazardous waste, treatment and/or disposal of contaminated soil at an off-site facility would be required to meet land disposal restrictions (LDRs) established under RCRA (40 Code of Federal Regulations [CFR] 268). LDRs establish disposal criteria (i.e., universal treatment standards [40 CFR 268.48]) and restrictions for RCRA hazardous wastes. LDRs require RCRA wastes with constituent concentrations exceeding universal treatment standards to be treated prior to disposal in a RCRA facility. Contaminated media to be treated and/or disposed of off-site must comply with LDRs for off-site treatment and/or disposal. Universal treatment standards for constituents of concern at the Site are presented on **Table 2**.

Wetlands/Floodplains. The 1993 Human Health and Ecological Evaluation (ABB-ES, 1993b) identified the drainage area south and east of the Warehouse as a wet meadow containing wetland plant species, and the bank along No Name Brook as a floodplain wetland. Remedial actions being conducted in the former Plourde/Lyons area that impact either of these areas need to comply with federal and state regulations for wetland and floodplain protection. Federal regulations include: Clean Water Act (40 CFR 230), Fish and Wildlife Coordination Act (16 United States Code 661), and Wetlands Executive Orders (EO-11990 and EO-119988) and the National Environmental Policy Act (40 CFR 6). State regulations include: Maine Natural Resources Protection Act Wetland Protection Rules (MEDEP Regulations Chapter 310), and Maine Site Location Development Law and Regulations (38 Maine Revised Status Annotated 481-490; MEDEP Regulations Chapter 375).

Soil Clean-Up Standards. Generic soil cleanup standards are being developed by the MEDEP. These standards incorporate USEPA Soil Screening Guidance (USEPA, 1996a, 1996b) when threats to groundwater are anticipated. These standards are currently undergoing management review in the MEDEP (MEDEP, 1997b). In lieu of MEDEP soil cleanup standards, USEPA generic Soil Screening Levels (SSLs), developed in USEPA Soil Screening Guidance, will be used to formulate soil remediation standards for use in this RAE in **Section 3.5**.

The USEPA guidance evaluates SSLs for three exposure pathways: (1) direct ingestion; (2) inhalation; and (3) migration to groundwater. USEPA SSLs for human exposure via inhalation are not considered in this evaluation because volatilization to ambient air is not a potential exposure pathway (see **Section 3.3**). The remaining two pathways were evaluated. The USEPA guidance indicates that when more than one exposure pathway is of concern, the lowest

SSL should be used. Consistent with the USEPA guidance, the lowest SSL was selected for each constituent in developing remediation standards.

Included in the MEDEP comments on the Work Plan (ABB-ES, 1997), MEDEP provided a methodology for considering multiple site contaminants (MEDEP,1997b). The guidance adjusts the SSLs for carcinogenic contaminants by dividing the generic SSL by the total number of contaminants at the site. Adjusted SSLs were calculated by dividing the generic SSL by the total number of Site contaminants that exceeded either human health or ecological evaluation criteria or SSLs. Constituents exceeding one of these criteria included methylene chloride, TCE, PCE, and trans 1,2-DCE.

3.4 Remediation Standards

Soil remediation standards for soils at the former Plourde/Lyons area were developed for use in this RAE to achieve the CAOs identified in Subsection 3.3: (1) Protection of human health by preventing exposure to contaminated subsurface soil; and (2) protection of groundwater from potential impacts of contaminated soil.

Constituent specific remediation standards were developed for each of these CAOs, and the lowest of the two was used to calculate the Site remediation standard in accordance with the MEDEP requirement to account for multiple contaminants at a Site. **Table 3** presents the remediation standards for each of the CAOs as well as the resultant standards calculated for the site. Assumptions used in developing the remediation standards for each of the CAOs is presented in the following paragraphs.

Protection of Human Health from constituents in subsurface soils: Two methods are available for development of remediation standards for protection of human health from constituents in subsurface soils: (1) use of the USEPA SSLs and (2) use of a site specific risk assessment. Typically, a site specific risk assessment could result in remediation standards less conservative than the USEPA SSLs. However, a site specific risk assessment for exposure to subsurface soils was not conducted at this Site. A risk assessment for exposure to concentrations present in surface soils was conducted (ABB-ES, 1993 b, c) The potential risk for exposure to surface soils is based on a more conservative scenario than one for exposure to subsurface soils and, therefore, concentrations evaluated in the surface soil exposure scenario could be safely applied to subsurface soils. However, the concentrations evaluated in the surface soil risk assessment were considerably lower than any concentrations detected in the subsurface and, therefore, are not useful in the determination of allowable site concentrations. Therefore the USEPA SSLs are being used at this site as

remediation standards for protection of human health. **Table 3** also contains the constituent-specific USEPA SSLs.

Protection of Groundwater: USEPA SSLs were also used to develop remediation standards for protection of groundwater. USEPA Soil Screening Guidance developed two sets of SSLs for migration to groundwater. One set of values (dilution-attenuation factor [DAF] 20 values) assumes that some dilution and attenuation of constituents will occur during transport through the saturated zone. The second set of values (DAF 1 values) assumes no dilution or attenuation will occur. The guidance states that, “a DAF of 20 is protective for sources up to 0.5 acres in size” and “analyses indicate that it can be protective of larger sources as well.” The area of significant contamination at the former Plourde/Lyons area, as shown in **Figure 7**, is approximately 0.8 acres in size, with the potential source area being concentrated along the drainage ditch and encompassing approximately 0.4 acres. Based on the small potential source area, the DAF 20 values were selected for use as SSLs for the migration to groundwater pathway.

3.5 Soil Exceeding Site Remediation Standards

Based on the sampling results, the aerial extent of contamination shown in **Figure 7** is consistent with the area of soil exceeding remediation standards developed for the Site, showing contours that indicate the extent of the residual PCE in the marine clay. Constituents detected in soil at concentrations exceeding remediation standards are located predominantly along the drainage ditch located in the former Plourde/Lyons area and are predominantly located from 8 to 12 feet bgs. Soil sampling results also exceeded remediation standards at TB-304 (PCE detected at 10-12 feet bgs at 10 mg/kg), MW-405A (PCE detected at 24 mg/kg, trans 1,1-DCE detected at 0.1 mg/kg, and TCE detected at 0.081 mg/kg at 10-12 feet bgs), and TB-403 (methylene chloride detected at 20-22 feet bgs at 0.055 mg/kg). Remedial alternatives developed in **Section 4.0** address soils exceeding remediation standards in the former Plourde/Lyons area.

Table 2
Universal Treatment Standards for Land Disposal

Constituent	RCRA Universal Treatment Standard (mg/kg)
Methylene Chloride	30
1,1-Dichloroethane	6
1,1,1-Trichloroethane	6
Trichloroethene	6
Tetrachloroethene	6
trans-1,2-Dichloroethene	30

Table 3
Site Specific Remediation Standards (all mg/kg units)

Site Data		Protection of Human Health	Protection of Groundwater		Lowest Evaluation Criteria	Site Specific Remediation Standards	
Constituent	Max Detection in Plourde-Lyons Area Clay	(Oct., 2001) USEPA Soil Screening Level (Residential)	(Oct., 2001) USEPA Soil Screening Level - DAF 20 Values	(May, 1997) MEDEP Remedial Action Guidelines for Contaminated Soils		Adjusted Standard for Multiple Constituents ¹	Remediation Standard
Methylene Chloride (C)*	25	85	0.019	0.02	0.019	0.006	0.006
1,1- Dichloroethane (N)	0.04	7,800	4.5	23	4.5	NA	4.5
1,1,1-Trichloroethane (N)	1.1	22,000	60	2	2	NA	2
Trichloroethene (C)	0.68	58	0.015	0.06	0.015	0.005	0.005
Tetrachloroethene (C)	4100	12	0.048	0.06	0.048	0.016	0.016
trans-1,2-DCE (N)	0.1	1,600	0.82	0.7	0.7	NA	0.7
* C = Carcinogenic N = Noncarcinogenic 1 = Lowest Eval. Criteria divided by number of carcinogenic contaminants found (3)							

4.0 POTENTIAL REMEDIAL ALTERNATIVES

The identification of potential remedial alternatives includes a process of identifying potential treatment technologies, screening technologies based on site and waste characteristics, and finally assembling the retained technologies into potential remedial alternatives to meet CAOs. That process is presented in the following subsections.

This revised evaluation of alternatives focuses on remediation of as much of the PCE impacted clay as is feasible, instead of strictly at meeting SSL derived clean up levels that were derived in the previous sections describing CAOs. The revised evaluation and the alternative selected reflect this strategy of maximizing cost effective mass removal in lieu of meeting specific clean up levels. This mass removal focus is more appropriate based on the conditions at the site and overall site strategy of protecting groundwater.

4.1 Initial Remedial Technology Screening

Table 4 contains the initial screening of available remedial alternatives that was conducted based on effectiveness and implementability in the Site conditions. Only technologies that could be implemented and have been proven effective in conditions comparable to those at the Site were retained for further consideration. Because the SSL derived remediation standards developed in **Section 3.0** are difficult to achieve with treatment technologies the evaluation considers the application of remedial technology the effect mass removal to the levels feasible, rather than eliminating any technology based on the fact that it may not be proven to attain the conservative remediation standards.

Table 4
Screening of Remedial Technologies

Technology	Description	Comments/Evaluation	Screening Results
<u>Institutional Controls</u>			
Deed Restrictions	Incorporation of land use restrictions into the deed of the property to limit intrusive activities and minimize potential exposure.	Would be coordinated and implemented after Plourde/Lyons response action.	Retained
Groundwater Monitoring	Monitor groundwater impacts and concentration trends through scheduled sampling of monitoring wells.	A long term monitoring plan is currently in place at the Site.	Retained
<u>In-Situ Treatment</u>			
Soil Vapor Extraction	Vacuum application and collection of soil gas to remove contaminants in the gas phase.	Not appropriate for the low permeability saturated clays that require treatment in the Plourde/Lyons Area	Eliminated
High Vacuum Extraction	High vacuum (20-30" Hg) application to extract water and gas from a single well and effect dewatering of contaminated zone.	Pilot Testing did not show high vacuum to be effective at mass removal or dewatering the Plourde/Lyons clay.	Eliminated
Reactive Iron/Source Mixing	Mixing of reactive iron filings with source material to subject any leaching PCE to reductive dechlorination. Tested experimentally on small trial projects – not a proven application.	Bench Testing of clay/iron mixtures did not show effective <i>in-situ</i> reduction of PCE with zero valence iron to be effective.	Eliminated
Bioremediation	Anaerobic microorganisms would be required to degrade PCE. Substrate would be delivered to the subsurface by injection to stimulate a mixed microbial population.	Not appropriate for the low permeability saturated clays that require treatment in the Plourde/Lyons Area. Substrate delivery is not feasible.	Eliminated

Table 4 - Continued
Screening of Remedial Technologies

Soil Flushing	Aqueous co-solvents or surfactants are cycled through the contaminated soil to remove contaminants for subsequent treatment.	Not appropriate for the low permeability saturated clays that require treatment in the Plourde/Lyons Area. Amendment delivery for flushing and water transport through the clay is not feasible.	Eliminated
Thermal Extraction	<i>In-situ</i> thermal process include vitrification, electrical resistance heating, and steam injection. Vitrification destroys the contaminant in place; Lower temperature heating technologies cause volatilization to allow subsequent extraction.	Steam coupled with vacuum extraction has not been shown to be effective relative to other proven and available technologies that have been retained.	Eliminated
Chemical Oxidation	Direct application of a strong oxidant such as peroxides or permanganates to the contaminated clay.	Direct mixing of hydrogen peroxide was tested with the contaminated clay and indicated successful treatment.	Retained
<u>Ex-Situ Treatment</u>			
Thermal Desorption	Excavated soil is processed using heat to volatilize contaminants that are either combusted within the system or captured for treatment.	Saturated clays require dewatering and bulking for handling.	Retained
Forced Aeration	Excavated soils are constructed into piles with extraction piping in a configuration that draws air through the soil pile. Volatilized contaminants are captured and treated.	Not appropriate for the low permeability saturated clays that require treatment in the Plourde/Lyons Area	Eliminated
<u>Disposal</u>			
Excavation/Off-Site Disposal	Excavated soils are shipped directly to a RCRA TDS facility for treatment/disposal	The fluid behavior of the clays make excavation questionable.	Retained

4.2 Bench and Pilot Scale Testing in Support of RAE Revisions

Ciba conducted pilot scale testing of high vacuum extraction at the request of MEDEP and based upon comments received on the draft RAE in 1998. Ciba also conducted some bench testing with reactive iron to evaluate the potential for creating an *in-situ* treatment process. These activities were conducted concurrent to the additional phases of investigation in the area. The most recent work in September 2001 investigated the feasibility of using hydrogen peroxide solution with mechanical mixing of the contaminated clay to evaluate potential for mass removal success using *in-situ* oxidation.

Neither the reactive iron nor the high vacuum dual phase extraction produced results positive enough to warrant further consideration regarding the implementation of these technologies. Peroxide oxidation of PCE has been successfully demonstrated at the field scale by the Department of Defense and also by several commercial vendors. Bench scale results using peroxide were positive enough to warrant the addition of *in-situ* chemical oxidation to the list of potential remedial alternatives.

4.3 Identification and Screening of Potential Remedial Technologies

Potential remedial technologies were identified and screened based on a review of literature sources, contact with vendors to obtain specific information and performance data, and experience in developing similar remedial solutions. Only technologies capable of treating Site constituents of concern and addressing CAOs were identified.

Initial screening evaluated potential technologies based on technical and administrative feasibility, implementability, and effectiveness. Both site and waste characteristics were considered in the screening process. Several site and waste characteristics for the former Plourde/Lyons area soil present technical and administrative limitations on soil treatment technologies. These characteristics include:

- vertically thin vadose zone;
- contamination in different subsurface soil deposits (silty sand and marine clay);
- soil contamination extending up to 15 feet into the marine clay layer;
- difficulty in excavating the marine clay layer due to its liquid behavior when disturbed;

- low hydraulic conductivity of the marine clay restricting water and air movement; and
- regulatory requirements to dispose of a soil classified as a RCRA hazardous waste.

These factors were considered during the identification and screening of potential remedial technologies. For those technologies retained and developed into alternatives, these factors will also be evaluated in the detailed analysis as applicable. **Table 4** identified and screened the remedial alternatives prior to conducting detailed analysis of the retained alternatives.

Soil vapor extraction (SVE) was retained in the original document for detailed analysis. In this revised evaluation SVE was more appropriately eliminated in the initial screening.

4.4 Development and Conceptual Description of Remedial Alternatives

Remedial technologies retained from the screening process represent an inventory of potential options considered suitable for remediation of contaminated soil in the former Plourde/Lyons area. In this section, remedial technologies retained from the screening process are combined to develop remedial alternatives that provide a range of options to address CAOs. The alternatives range from eliminating the need for long-term management by removing or destroying contaminants to the maximum extent feasible, to alternatives including little or no treatment that provide protection of human health, and the environment by controlling exposure to contaminants. The following subsections present the remedial alternatives developed for the Site and the conceptual design for each alternative.

4.4.1 Alternative 1 - Limited Action

The Limited Action Alternative for the Plourde/Lyons area soil consists of land use restrictions and continued groundwater extraction, treatment, and monitoring. Land use restrictions in the form of deed restrictions would prohibit development of the Site and limit human contact with contaminated soil.

The Limited Action Alternative does not involve any remedial processes. Components of this alternative include only administrative tasks (i.e., deed restrictions). No conceptual design is required for this alternative. Groundwater extraction, treatment, and monitoring activities described in **Section 2.4** would continue to be conducted at the H&H Site under this alternative.

4.4.2 Alternative 2 - Excavation and Off-Site Treatment and/or Disposal

This alternative includes the following components:

- Site Preparation
- Excavation of Contaminated Soil
- Transport of Soil to Off-Site RCRA Treatment, Storage, and Disposal (TSD) Facility
- Site Restoration
- Ongoing Groundwater Remedial Activities

Site Preparation. Site preparation for this alternative would include clearing and grubbing of approximately one acre to conduct the excavation, preparation of soil conditioning, truck loading, and truck decontamination areas, construction of access road to the area of excavation, and decommissioning of monitoring wells (MW-208, MW-404A, MW-407A, and MW-401B), and extraction well EW-404 and the associated piping, and controls.

Excavation of Contaminated Soil. Excavation of contaminated soil would be accomplished using conventional construction equipment such as front-end loaders, backhoes, and dump trucks. Due to the shallow nature of the groundwater at the Site, groundwater flowing into the excavation, as well as precipitation, will need to be collected and removed from the excavation. This would be accomplished by using submersible pumps placed within the excavation limits to pump out the water. This evaluation assumes that water would be treated in the existing groundwater treatment system at the Site. Because of the low hydraulic conductivity of the shallow silty sand aquifer, a large volume of groundwater is not anticipated to be collected in the excavation.

The depth of the excavation is expected to extend up to 12-15 feet bgs and would extend into the marine clay layer at the Site. In order to stabilize the excavation sidewalls and enable excavation of the marine clay, it is anticipated that sheet piles would be used in the excavation process. Approximately 1,100 linear feet of sheet piling would need to be installed to a depth of approximately 20 feet bgs. The estimated amount of contaminated soil to be excavated is approximately 10,900 cubic yards (cy) (18,530 tons). This estimate includes material (approximately 400 cy) used in constructing the access roads to the excavation. It is assumed that during excavation activities material used to construct the access roads would become contaminated.

Once excavated, the soil would be staged in a temporary stockpile to allow dewatering and soil conditioning. Soil conditioning would likely consist of addition of lime or cement to dewater the soil to meet handling requirements at the disposal facility. A bulking factor of 10 percent was assumed after soil

conditioning. Based on soil bulking, the total volume of contaminated material to be disposed is estimated to be 11,900 cy (20,838 tons).

Confirmation sampling would be conducted as the excavation progresses to ensure that all soil exceeding remediation standards has been removed. For this evaluation, it is assumed that 25 confirmatory samples would be collected from the excavation floor, and 25 confirmatory samples would be collected from excavation side wall. Samples would be analyzed for the constituents listed in **Table 3**, and the results would be compared to remediation standards to determine if additional excavation was required. Areas where remediation standards were exceeded would be excavated and resampled.

Transport and Disposal of Soil at Off-Site RCRA TSD Facility. A licensed hazardous waste disposal contractor would be contracted to transport and dispose of excavated soil. Treatment and/or disposal would occur at permitted RCRA TSD facility. Excavated and conditioned soil would be sampled and analyzed prior to shipment to determine proper RCRA TSD disposal requirements. Analytical results would be compared to universal treatment standards (**Table 2**) to determine if the soil required treatment prior to disposal in a TSD facility. Once disposal requirements were identified, soil would be loaded onto trucks for transport to the appropriate off-site permitted RCRA TSD facility. For this evaluation, it was assumed that one composite sample would be collected and analyzed for every 850 tons (500 cy) of material to be disposed. Analysis would include constituents presented in **Table 2** and RCRA characteristics (i.e., TCLP metals, reactive cyanide, reactive sulfide, ignitibility, and pH).

TSD facilities were contacted to provide information on treatment and/or disposal of contaminated soil from the Site. Soil meeting LDRs would be disposed of in a RCRA Subtitle C Landfill without treatment. Soil exceeding RCRA disposal criteria would be incinerated prior to disposal. Waste Management Inc. operates a RCRA Subtitle C Landfill in Model City, New York, and an incineration facility in Port Arthur, Texas. Disposal costs for these facilities were used in this evaluation.

For the purpose of this RAE, it is assumed that approximately 20 percent (4,077 tons) of the contaminated soil would exceed universal treatment standards and would require incineration. The remaining 80 percent (16,306 tons) of excavated soil was assumed to be disposed of in a RCRA Subtitle C Landfill. This evaluation assumed that 350 tons of material per day would be transported from the Site for treatment and/or disposal. In this alternative would be expected to continue for three to four months.

Site Restoration. Once excavation and confirmation sampling activities were completed, site restoration would commence. Site restoration activities would consist of removal of sheet piling, placement and grading of clean backfill in the excavation, reinstallation of monitoring and extraction wells, and reinstallation of groundwater piping and controls associated with the groundwater extraction system. Once these activities were completed, the area would be mulched, fertilized, and seeded.

Ongoing Groundwater Remedial Activities. Groundwater extraction, treatment, and monitoring activities described in **Section 2.4** would continue to be conducted at the H&H Site under this alternative.

4.4.3 Alternative 3 - Excavation, On-Site Thermal Desorption, and On-Site Disposal

This alternative includes the following components:

- Site Preparation
- Excavation of Contaminated Soil
- On-Site Treatment Using Thermal Soil Desorption
- On-Site Disposal of Treated Soil
- Site Restoration
- Ongoing Groundwater Remedial Activities

Site Preparation. Site preparation for this alternative would include clearing and grubbing of approximately one acre to conduct the excavation, preparation of a treatment area, construction of access road to the area of excavation, decommissioning of monitoring wells (MW-208, MW-404A, MW-407A, and MW-401B) and extraction well EW-404 and the associated piping and controls, and mobilization of a thermal treatment unit.

Excavation of Contaminated Soil. The excavation process for this alternative would be similar to that described in **Section 4.2.3** for Alternative 2.

On-Site Treatment Using Thermal Soil Desorption. A thermal desorption system is designed to volatilize and remove organic contaminants from excavated soil through the use of air, heat, and/or mechanical agitation. The thermal unit consists of a treatment vessel, usually a rotary dryer or fixed bed, a heat source, and a carrier gas. The soil is heated to a temperature of 200 to 800°F to volatilize water and organic contaminants. Off gases from the system are collected and typically treated either in a secondary combustion chamber or catalytic oxidizer, and/or passed through granular activated carbon prior to discharge. The thermal desorption process generally does not destroy organic

contaminants and combustion by-products are not formed. System variables such as feed rate, temperature, and residence time of the solids can be adjusted to provide maximum efficiency of the unit.

A number of vendors have developed mobile units of various sizes that are capable of treating up to 220 tons of waste material per day (approximately 130 cy of soil per day). These units require a level set-up area, water, power, and adequate access roads (USEPA, 1991). Smaller mobile units are available for sites with relatively small volumes. These units typically process 3 tons of waste per hour (approximately 2 cy of soil).

For this evaluation, a batch thermal treatment system was evaluated. The system uses lifts of soil placed into covered treatment piles with air injection and extraction piping placed within the soil lifts. Typical piles sizes range from 1,000 to 1,800 tons of soil per pile. Piles require an area approximately 100 feet by 40 feet for construction and are typically 12 feet high. To reduce downtime and decrease the duration of the remediation, multiple piles can be used at a site.

The batch thermal system evaluated uses air heated by propane to temperatures of up to 600-800°F is delivered to the soil pile and promotes volatilization of contaminants. Once the air contacts the soil and volatilizes contaminants, it is collected and removed from the pile by the extraction piping. Up to 90 percent of the off gas from the pile is recycled to the propane burner and reused. Off gas that is not recycled is treated in a catalytic oxidizer prior to discharge to the atmosphere. Air emissions from this type of unit are typically less than 0.1 pounds per hour. Piles are typically treated for a period of five to seven days. Treatment duration is dependent upon operating conditions, soil types, contaminant concentrations, and remediation standards. Treatment duration for the Site would be determined during bench- or pilot-scale testing.

This evaluation assumes the use of two treatment piles, each capable of batch treating 1,000 tons of soil in a five-day treatment period to achieve remediation standards. Based on this batch size, 20-21 treatment piles would be required to treat the estimated 20,383 tons of contaminated soil from the former Plourde/Lyons area. Treatment would expected to continue for four to five months.

On-Site Disposal of Treated Soil. After treatment, soil would be sampled and analyzed to ensure that remediation standards were obtained during treatment. For this evaluation, two composite samples were assumed to be collected from each pile after treatment. Based on a batch size of 1,000 tons, sampling frequency would be one sample per 500 tons of soil treated. Soil meeting remediation standards would be returned to the excavation for use as backfill.

If residual concentrations of contaminants did not meet remediation standards after initial treatment, the soil would undergo additional thermal treatment or be disposed off-site in a RCRA TSD facility. For this evaluation, it is assumed that all treated soil would meet remediation standards and would be used as backfill on the Site.

Site Restoration. Once excavation and confirmation sampling activities were completed and treated soil was approved for backfill, backfilling of the excavation would commence. Backfilling operations would continue until all treated soil has been placed back into the excavated area. Site restoration activities would also include removal of sheet piling, installation of monitoring and extraction wells, reinstallation of groundwater piping and controls associated with the groundwater extraction system, and demobilization of the thermal treatment unit and support equipment. Once these activities were completed, the area would be mulched, fertilized, and seeded.

Ongoing Groundwater Remedial Activities. Groundwater extraction, treatment, and monitoring activities described in **Section 2.4** would continue to be conducted at the H&H Site under this alternative.

4.4.4 Alternative 4 – *In-Situ* Chemical Oxidation

This alternative includes the following components:

- Site Preparation
- Reagent Application and Mixing
- Restoration of the Area
- Supplemental Groundwater Monitoring
- Ongoing Groundwater Remedial Activities

Site Preparation. Site preparation for this alternative would include clearing and grubbing of approximately 0.25 acre to allow access to the area of contaminated soil. Once the area has been cleared, overburden will be scraped back to form a containment berm. A secondary containment measure consisting of silt fence and/or hay bales will be set up to provide secondary containment.

Application of the Peroxide to the Contaminated Clay. The peroxide solution is mixed with the exposed clay from the surface to a depth of approximately 10 feet. At least 5 feet of clean clay beneath the contaminants will remain undisturbed to provide protection for the underlying aquifer. Mixing will be implemented using a 6 foot diameter tiller head unit mounted on an excavator. A second track excavator with a standard bucket will be mobilized for additional mixing as necessary. The peroxide solution is gravity fed directly from the

tanker unit used for over the road delivery, through PVC piping and flexible hose directly into the excavation for mixing. Additional potable water will be available should it be necessary to make the clay more fluid to facilitate mixing.

After thoroughly mixing the clay and peroxide the area will be permitted to settle until all the peroxide has reacted and there is no more oxygen off-gassing. Post treatment sampling of the treated clay will then be conducted.

Site Restoration. Once the peroxide application activities are completed, the area would be restored to the original grade using the original overburden, then the area will be mulched, fertilized, and seeded.

Ongoing Groundwater Remedial Activities. Groundwater extraction, treatment, and monitoring activities described in **Section 2.4** would continue to be conducted at the H&H Site under this alternative.

5.0 EVALUATION OF REMEDIAL ALTERNATIVES

The 1997 Compliance Order required this evaluation of remedial alternatives to detail protectiveness of human health and the environment; long-term reliability and effectiveness; reduction of toxicity, mobility, or volume; implementability; and cost for these actions. These evaluation criteria are described in **Table 6**. The following subsections present the evaluation of these criteria for each of the alternatives retained from **Section 4.0**.

Table 6
Criteria for Evaluating Remedial Alternatives

Protectiveness of Human Health and the Environment	Describes how each alternative, as a whole, provides protection to human health and the environment.
Long term Reliability and Effectiveness	Evaluates the extent and effectiveness of the controls that may be required to manage the treated residuals and/or untreated waste at the Site
Reduction in Toxicity, Mobility or Volume	<p>Evaluates USEPA's preference for treatment (i.e., technologies that permanently reduce toxicity, mobility or volume of the contamination.</p> <p>Examines the effectiveness of alternatives in protecting human health and the environment during the construction/implementation period until the remedial objectives are met.</p>
Implementability	Examines the demonstrated performance of specific treatment technologies and the ability to meet remedial objectives, evaluates the required coordination with agencies, and permitting requirements.
Cost	Evaluates the capital and operating costs of each alternative.

5.1 Alternative 1 - Limited Action

The following subsections present the detailed evaluation of Alternative 1 - Limited Action. This alternative is focused on meeting the CAO established for protection of human health by preventing exposure to contaminated subsurface soil. Groundwater monitoring would continue to be conducted to evaluate the impact of contaminated soil on Site groundwater, and to evaluate the performance of the groundwater extraction system in maintaining the groundwater capture zone. However, potential impacts of contaminated soil would not be changed.

5.1.1 Protectiveness of Human Health and the Environment

The limited action alternative would provide protection of human health by restricting land use and minimizing the potential for human contact with contaminated soil. No protection to groundwater would occur under this alternative.

Due to the presence of contamination in both soil and groundwater at upgradient areas of the H&H Site, soil and groundwater remediation and groundwater monitoring activities would continue as part of the overall H&H Site remediation.

5.1.2 Long-Term Reliability and Effectiveness

Deed restrictions would be a reliable method of minimizing the potential for human exposure to contaminated soil. Long-term monitoring of groundwater quality and the extent of the groundwater capture zone would provide effective controls at monitoring the impact of contaminated soil remaining in the former Plourde/Lyons area.

5.1.3 Reduction of Toxicity, Mobility, or Volume

No reduction of toxicity, mobility, or volume of contaminated soil would occur under the limited action alternative.

5.1.4 Implementability

Deed restrictions could be easily incorporated into the deed for the property. Currently, Ciba owns all of the land within the former Plourde/Lyons area with the exception of the land along the railroad tracks (approximately 32 feet of both sides of the track) located on the southwestern side of the Warehouse owned by Guilford Transportation Industries, Inc. Because of ongoing Site remedial activities, Ciba has no plans for selling or transferring the property in the near future.

5.1.5 Cost

Costs associated with this alternative consist of administrative costs associated with implementing deed restrictions. Groundwater monitoring costs are not included in this estimate, because they are being incurred under other remedial actions being undertaken at the Site. The total cost of Alternative 1 was estimated at \$14,000. Costs associated with this alternative are presented in **Appendix A**.

5.2 Alternative 2 - Excavation and Off-Site Treatment and/or Disposal

The following subsections present the detailed evaluation of Alternative 2 - Excavation and Off-Site Treatment and/or Disposal. This alternative is focused on excavating and disposing of soil exceeding remediation standards to meet CAOs established for protection of human health and minimizing potential impacts of contaminated soil on groundwater.

5.2.1 Protectiveness of Human Health and the Environment

Alternative 2 would provide protection to human health and the environment by excavating and treating and/or disposing of all soil exceeding remediation standards at an off-site facility. Confirmation sampling would be conducted on the excavation area to ensure that all soil exceeding remediation standards was removed. This alternative would meet all CAOs established in this RAE.

During implementation of remedial actions under this alternative, health risks would be associated with operating heavy equipment, and potential worker exposure to contaminated soil during excavation, transportation, and treatment and/or disposal. To minimize these risks, a site-specific Health and Safety Plan would be developed and implemented.

Due to the presence of contamination in both soil and groundwater at upgradient areas of the H&H Site, soil and groundwater remediation and groundwater monitoring activities would continue as part of the overall H&H Site remediation.

5.2.2 Long-Term Reliability and Effectiveness

Removal and off-site treatment and/or disposal would not leave any treatment residuals on site in the former Plourde/Lyons area. Off-site treatment and disposal in a permitted RCRA TSD facility provides regulated management of contaminated material.

Contaminated groundwater present at areas of the H&H Site upgradient of the former Plourde/Lyons area could potentially impact backfilled soil. Long-term monitoring of groundwater quality and the extent of the groundwater capture zone would provide effective controls at monitoring contamination both inside and outside of the former Plourde/Lyons area.

5.2.3 Reduction of Toxicity, Mobility, or Volume

Removal and off-site treatment and/or disposal would not leave any treatment residuals on site in the former Plourde/Lyons area. Off-site treatment and disposal in a permitted RCRA TSD facility provides regulated management of

contaminated material in a secured landfill. Material treated prior to disposal would be reduced in toxicity; however, material meeting universal treatment standards would not be treated prior to disposal and would not experience a reduction in toxicity. The mobility of constituents in all soil excavated would be reduced since the material would be disposed in a lined and secured RCRA Subtitle C Landfill.

5.2.4 Implementability

This alternative uses common excavation techniques and readily available TSD facilities to conduct the remedial actions. General contractors with Hazardous Waste Health and Safety Training (29 CFR 1910.120 [e]) and certified hazardous waste disposal contractors are available to perform these services and meet the removal objectives.

Administrative issues that require consideration include manifesting material for disposal off-site, coordinating with Guilford Transportation Industries, Inc. for access over the railroad, and coordinating removal actions with various federal, state, and local agencies. Remedial actions undertaken near the banks of No Name Brook would need to be conducted in accordance with wetland and floodplain regulations.

5.2.5 Cost

The total cost of Alternative 2 was estimated at \$10,436,000. Costs associated with this alternative are presented in **Appendix A**. The estimate includes capital costs, consisting of direct and indirect costs. There are no operation and maintenance costs associated with this alternative.

Direct costs include expenditures for the equipment, labor, and materials necessary to prepare the Site, excavate, transport, and dispose of soil, and restore the Site. A 20 percent contingency was included in the direct costs to account for unforeseen project complexities (e.g., adverse weather conditions and additional soil volume).

Indirect costs include additional administrative, engineering, and legal services associated to the remedial action. These costs include engineering expenses, legal fees, and health and safety costs.

5.3 Alternative 3 - Excavation, On-Site Thermal Desorption, and On-Site Disposal

The following subsections present the detailed evaluation of Alternative 3 - Excavation, On-Site Thermal Desorption, and On-Site Disposal. This

alternative is focused on excavating and treating soil exceeding remediation standards to meet CAOs established for human health and minimizing potential impacts of contaminated soil on groundwater. Once the soil is treated to meet remediation standards, the soil would be used to backfill the excavation.

5.3.1 Protectiveness of Human Health and the Environment

Alternative 3 would provide protection to human health and the environment by excavating and treating all soil exceeding remediation standards prior to backfilling the treated soil. Confirmation sampling would be conducted on the excavation area to ensure that all soil exceeding remediation standards was removed. Sampling would also be conducted on treated soil to ensure that thermal treatment reduced contaminant levels to concentrations below remediation standards. This alternative would meet all CAOs established in this RAE.

During implementation of remedial actions under this alternative, health risks would be associated with operating heavy equipment and potential worker exposure to contaminated soil during excavation and treatment. To minimize these risks, a site-specific Health and Safety Plan would be developed and implemented.

Due to the presence of contamination in both soil and groundwater at upgradient areas of the H&H Site, soil and groundwater remediation and groundwater monitoring activities would continue as part of the overall H&H Site remediation.

5.3.2 Long-Term Reliability and Effectiveness

Treatment of soil by thermal desorption would permanently reduce constituent concentrations in the treated soil. Treated soil would be sampled prior to use as backfill to ensure that thermal treatment reduced contaminants levels to concentrations below remediation standards.

Contaminated groundwater present at areas of the H&H Site upgradient of the former Plourde/Lyons area could potentially impact backfilled soil. Long-term monitoring of groundwater quality and the extent of the groundwater capture zone would provide effective controls at monitoring contamination both inside and outside of the former Plourde/Lyons area.

5.3.3 Reduction of Toxicity, Mobility, or Volume

Treatment of contaminated soil by thermal desorption would permanently remove constituents from soil, thus reducing the toxicity of the soil and the potential for the soil to act as a source of groundwater contamination.

5.3.4 Implementability

This alternative uses common excavation techniques and readily available treatment methods to conduct the remedial actions. Several vendors with Hazardous Waste Health and Safety Training (29 CFR 1910.120 [e]) are available to provide thermal treatment units. Thermal desorption has been used full-scale to remediate soils containing similar contaminants at several sites in New England.

Coordination with federal, state, and local agencies would be required to implement this alternative. Administrative issues that require consideration include MEDEP policy on waiving RCRA permitting requirements for on-site treatment and backfill, coordinating with Guilford Transportation Industries, Inc. for access over the railroad, and coordinating remedial actions with various federal, state, and local agencies. Remedial actions undertaken near the banks of No Name Brook would need to be conducted in accordance with wetland and floodplain regulations.

5.3.5 Cost

The total cost of Alternative 3 was estimated at \$4,801,000. Costs associated with this alternative are presented in **Appendix A**. The estimate includes capital costs, consisting of direct and indirect costs. A description of direct and indirect costs is presented in **Section 5.2.5**. There are no operation and maintenance costs associated with this alternative.

5.4 Alternative 4 – *In-Situ* Chemical Oxidation

The following subsections present the detailed evaluation of Alternative 4 – *In-Situ* Chemical Oxidation. This alternative is focused on treating the clay in place to effect mass removal by destruction of the PCE to mineralization products in place to meet CAOs established for human health and minimizing potential impacts of contaminated soil on groundwater.

5.4.1 Protectiveness of Human Health and the Environment

The risk issues associated with this treatment technology are very short duration exposure concerns during the implementation of the reagent mixing process. Once the oxidation process has been implemented the PCE risk has

been effectively removed from the location. It should be noted that if the contaminated clay could be simply excavated and disposed of at a permitted landfill the same oxidation technology would be applied at the disposal facility in order to meet LDRs for this material.

5.4.2 Long-Term Reliability and Effectiveness

The oxidation technology a destructive process which mineralizes the PCE. No continuing source of PCE exists for the area to be treated so this mass removal action can be considered permanent and non-reversible (i.e, there will be no means for contaminant “rebound”). The effectiveness of the treatment depends solely upon the oxidant dosage and complete mixing with the contaminated clay.

5.4.3 Reduction of Toxicity, Mobility, or Volume

Toxicity and mobility factors are significant with the PCE contamination in this area. Although the contamination is contained in marine clay, PCE can still exhibit mobility due to its low viscosity and high density. Volume of the contaminant is not an issue. The destructive oxidation will essentially eliminate toxicity and mobility risk associated with the PCE. The oxidation products are short lived organic acids (such as dichloroacetic acid) of minimal toxicity in the concentrations possible based on the amount of parent compound. This is in contrast to reductive dechlorination processes, which can create degradation products (vinyl chloride) that are more toxic than parent compound.

5.4.4 Implementability

Chemical oxidation technology is typically more appropriate for *ex-situ* processes due to the inherent difficulties in contacting reagents with contaminants uniformly in the subsurface *in-situ*. The oxidation process evaluated in this case more resembles an *ex-situ* process because of the physical mixing of the clay with the peroxide reagent. Ciba conducted a test pit evaluation of the hot spot in the Plourde-Lyons clay to assess the feasibility of removing the uncontaminated overburden to expose the clay for the mixing action of the treatment process. The soil type permitted this type of excavation strategy. The fluid nature of the clay, which has been described in previous submittals, also will permit thorough mixing of the reagent with the contaminated clay to the target depths.

5.4.5 Cost

The total cost of Alternative 4 was estimated at \$41,700. Costs associated with this alternative are presented in **Appendix A**. There are no operation and maintenance costs associated with this alternative.

5.5 Comparative Evaluation

A comparative cost evaluation of the alternatives is presented on **Table 5**.

Table 5
Remedial Alternative Cost Comparison

Alternative 1 - Limited Action	\$14,000.
Alternative 2 - Excavation and Off-Site Treatment/ Disposal	\$10,436,000.
Alternative 3-On-Site Thermal Desorption, and On-Site Disposal	\$4,801,000.
Alternative 4 – <i>In-Situ</i> Chemical Oxidation	\$41,700.

5.6 Recommendations

Based on the collection and analysis of additional sampling data and treatability testing at the bench and pilot scale, the previous recommendation for Alternative 1 - Limited Action has been revised to a new more proactive recommendation for mass removal using *in-situ* oxidation technology. A mass removal strategy has been discussed with MEDEP and is considered appropriate in lieu of meeting SSL derived clean up levels.

This mass removal alternative, in conjunction with other remedial actions being conducted at the H&H Site (i.e., groundwater extraction, treatment, and monitoring), provides a site-wide remediation strategy that manages existing contamination within H&H Site boundaries.

This proposed alternative includes *in-situ* treatment of approximately 400 cubic yards soil that is significantly contaminated. This treatment has been limited to the highly contaminated materials for the following reasons:

1. The physical limitations related to the difficulty in exposing the saturated clay that exhibits liquid behavior.
2. Diminishing return from additional treatment of soil that exhibit low contaminant concentrations.

3. Protection of the deep aquifer is the primary objective of this RAE. Chemical oxidation of the “hot spot” will then make reliance upon containment by the non-impacted clay below the residual contamination more appropriate.

This alternative still provides protection to human health by implementing deed restrictions, prohibiting development of the former Plourde/Lyons area and limiting potential human contact with contaminated soil. Potential impacts to groundwater from contaminated soil would be significantly reduced.

Groundwater extraction, treatment, and monitoring will continue, and the effectiveness of groundwater remedial activities will continue to be evaluated. Continued monitoring of the extraction system will be used to evaluate the extent of the established groundwater capture zone and improvement provided by the new extraction point. Monitoring of groundwater quality would be used to evaluate potential impacts soil contamination may be having on Site groundwater. The existing groundwater treatment system has available capacity to treat the increased flow from additional extraction.

6.0 Remedial Action Implementation Plan

6.1 Objective

The oxidation of the Plourde-Lyons clay is focusing treatment within the aerial extent shown as the 100 mg/kg contour that was shown in **Figure 7**. The vertical extent of the targeted contamination varies but in general once the uncontaminated overburden has been removed the treatment depth will be from 6 to 8 feet. The analytical data indicate that the contaminant mass resides in a lens shape across the area to be treated. The objective of the oxidation is to:

- minimize contact of peroxide with uncontaminated clays and overburden to avoid wasting oxidant, and
- maximize the mixing and uniform distribution of the peroxide within the targeted treatment boundary.

The objective is mass removal by mineralization of the PCE contained in the clay.

6.2 Permitting Requirements

There will be no permanent alterations to either the existing topography or the environmental conditions at the ground surface after the remediation has been implemented. Because the extents of the excavation are located greater than 100 feet from No Name Brook no specific wetlands permitting is necessary. Dig Safe notification will be completed prior to the remedial action.

6.3 Process Description

The following subsections describe the components of the *in-situ* chemical oxidation remediation process anticipated for the Plourde/Lyons clay. The Site Plan and proposed layout of the remedial operation is shown in **Figure 14**.

6.3.1 Overburden Removal

The area will be cleared and grubbed prior to excavation. An exclusion zone will be established that will encompass the excavation area and the perimeter area where the mixing equipment will be operating. The exclusion zone will be roped off with safety tape to the aerial extent shown in **Figure 14**.

After clearing and grubbing is completed the overburden will be pushed or dragged back using a track hoe to expose the contaminated clay. The elevation of the drainage course will serve as the upper bound of the clay to be treated in conjunction with visual observation and PID measurements. The overburden will also form a containment berm around the treatment area. Additional overburden will be stockpiled as necessary.

A secondary containment around the soil berm will be constructed of silt fencing and/or hay bales. The exclusion zone will extend beyond the secondary containment wall and will be roped off using signs and reinforced yellow warning tape. The extent of the exclusion zone is shown in **Figure 14**. The peroxide tanker until will be located within the exclusion zone for additional safety.

Because this implementation is anticipated to take a maximum of 5 working days, the installation of a temporary drainage feature to re-route the drainage course to address precipitation is not included in this plan. Implementation will be coordinated with hospitable weather for this remedial action to the extent possible.

The entire supply of peroxide solution will be fed into the excavation on the day that it is delivered to the Site so that there are no overnight storage or protection requirements for hazardous material.

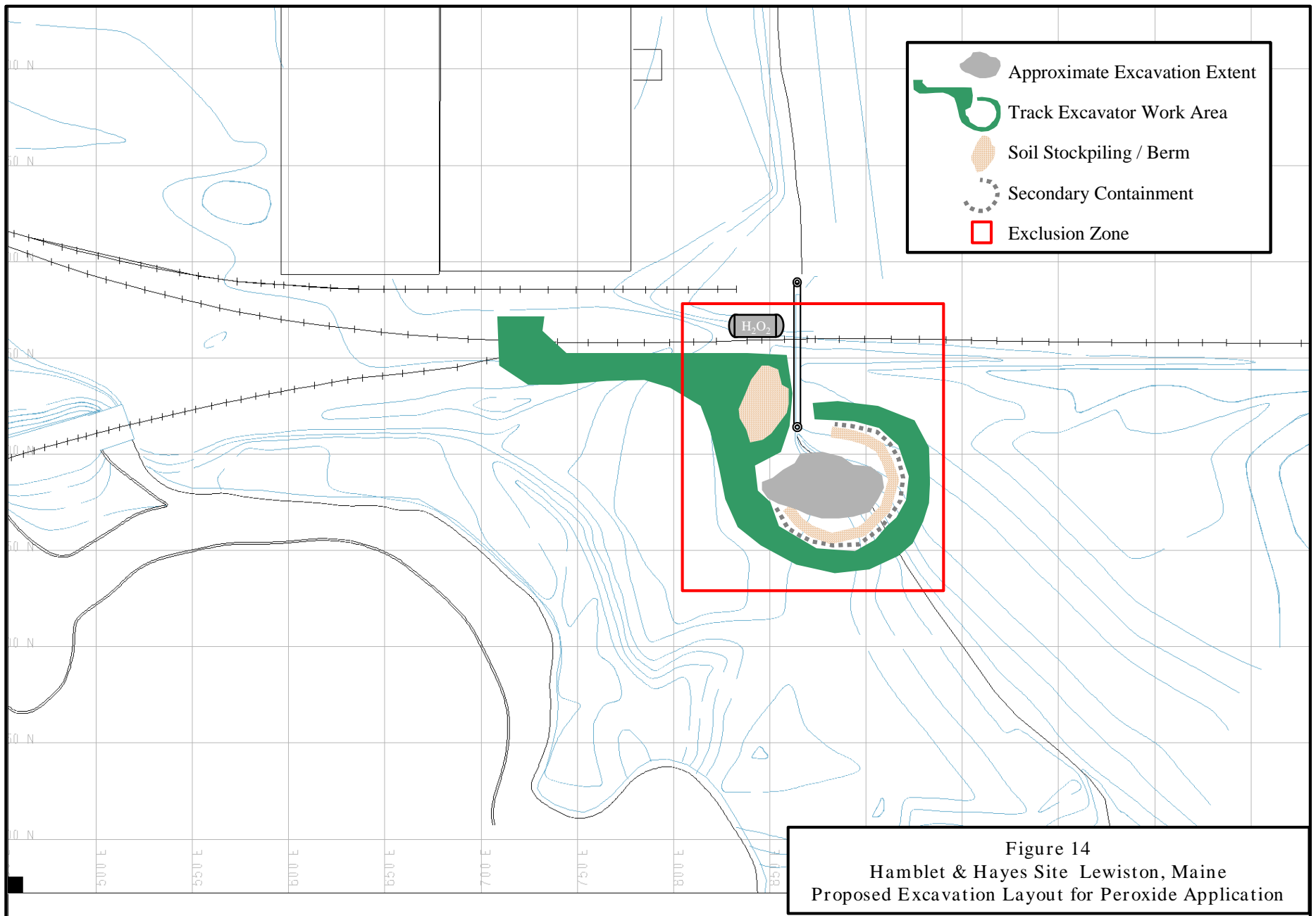
6.3.2 Oxidant Application

Peroxide will be manually added through pvc piping to permit application across the treatment area and additional application in the locations where the highest PCE concentrations were measured. Water will also be added if necessary to make the clays fluid enough to permit mixing to the desired depths. The peroxide will be added slowly in step wise manner to control the volume increase that will occur in the clay once the reaction begins to release oxygen gas. Dosing in an exact uniform manner from the peroxide feed line is not necessary because of the thorough mixing of the clay with the excavator mounted tiller attachment (and additional track hoe bucket as necessary). It may take several hours to complete the addition of the total peroxide dose and complete the mixing of the clay.

6.3.3 Backfill of Excavation / Restoration

No monitoring wells are within the planned treatment area. Monitoring well 401B is at the southern extent of the treatment zone and will not be physically disturbed during this implementation. The original grade will be restored and re-vegetated. Ciba has made a provision to relocate Extraction Well #4 to the

location of the treated excavation by placing a shallow standpipe within a coarse gravel pack. Although very little water is expected to be extracted from the clay it should be more productive than Extraction Well #4 has been to date. The well can be moved into the new stand pipe at a later date. This modification to the shallow groundwater extraction system will be proposed in the Annual Operations Report for 2001.



6.4 Remedial Action Health and Safety Plan

The specific health and safety plan for this remedial action focuses primarily on the excavation and on the handling and application of the hydrogen peroxide solution. General excavation and trenching guidelines that will be followed as part of the overall health and safety plan provided by Clean Harbors Environmental Services, is included in **Appendix B**. All site personnel working within the exclusion zone will be required to have 40 hour Hazwoper certification and have a current annual refresher status.

6.4.1 Hydrogen Peroxide Overview

Hydrogen Peroxide (H_2O_2) is one of the most versatile, dependable and environmentally desirable chemicals available today. The safety and efficiency of its operations have led to the development of numerous applications.

Hydrogen peroxide is an oxidizing agent for organic and inorganic chemical processing as well as semi-conductor, applications bleach for textiles and pulp, and a treatment for municipal and industrial waste. The versatility of hydrogen peroxide is evidenced by the variety of oxidation potentials and pH ranges hydrogen peroxide can act as an oxidizer. In the acid pH range un-catalyzed hydrogen peroxide is a moderate oxidizer, while catalyzed with iron it becomes a powerful oxidizer. In the alkaline pH range hydrogen peroxide can compete with hypochlorite as an oxidizer. Because of hydrogen peroxide's favorable properties, numerous applications such as bleaching, odor control, and wastewater treatment have been developed.

6.4.1.1 Properties of Hydrogen Peroxide

Hydrogen peroxide (H_2O_2) is a clear, colorless, inorganic liquid with an acidic pH. Because of the complete solubility of hydrogen peroxide in water, solutions of a wide range of concentrations can be made. The amount of H_2O_2 present is expressed as a percent of the solutions weight. Thus, ten pounds of a 35% solution contains 3.5 pounds of hydrogen peroxide and 6.5 pounds of water.

Under normal conditions hydrogen peroxide is extremely stable with demonstrated losses of less than 1% per year under ambient conditions. Heat and oxygen are generated during peroxide decomposition and even abnormal decomposition is easily handled by properly designed storage and handling systems. However, if severe contamination occurs or the solution is heated to extremely high temperatures, relieving devices may not be able to dissipate the volume of gas generated and the system may be over-pressured.

Hydrogen peroxide is not considered to be explosive, but explosive vapors can be formed when peroxide is mixed with certain organic materials. Also, hydrogen peroxide is not flammable, but does generate large amounts of oxygen during decomposition that supports combustion.

6.4.2 General Handling Requirements for Hydrogen Peroxide

When designing and constructing hydrogen peroxide storage and handling equipment, four rules govern the use of H_2O_2 :

Never contaminate- hydrogen peroxide can be contaminated by heat or energy, by contact with incorrect materials of construction or by externally introduced materials. Indications of contamination are activation of relief devices, peroxide is rapidly bubbling, temperatures are increasing or steam is evolving from the peroxide solution.

- Peroxide is extremely stable at ambient temperatures with losses of less than 1% per year at 72 deg F, but assay loss increases with temperature rise. For example, losses are 1% per week at 150 deg F and are 2% per day at 218 deg F.
- Hydrogen peroxide is compatible with a select list of materials. High purity aluminum and low carbon stainless steel as well as polyethylene, is acceptable for storage tanks. Piping is made from low carbon stainless steel or high purity aluminum and gaskets from teflon or teflon related products. Materials to avoid are copper, brass carbon steel, lead and lubricating oils. All wetted surfaces must be thoroughly cleaned and passivated.
- Historically, severe accidents involving hydrogen peroxide result from gross contaminations. Examples are wrong materials delivered to a storage tank, process backfeeds into peroxide storage tanks or used peroxide is returned to original container.

There will be no mixing or dilution of the peroxide solution, which will be used in the remedial action “as delivered”. The opportunity for contamination of the peroxide is minimized by using the solution directly from the approved shipping container from the manufacturer.

Never confine- hydrogen peroxide always decomposes, only the rate varies. Any peroxide storage and handling system must be designed with relief devices where peroxide may be trapped. For example, relief devices are required between isolation valves or between a pump and a valve. All ball valves must be specially designed with vented cavities.

The peroxide solution is being shipped directly from FMC Inc., in a bulk transport container specified by the supplier as meeting all DOT and other appropriate requirements. The peroxide solution will be fed directly into the excavation by gravity from the container used for transport, with no intermediate containers used. No pumps will be employed to move the peroxide solution.

Never contact personal contact and contact with flammable or combustible materials must be avoided. Personal Protective Equipment is required and varies by the task to be performed. Chemical safety goggles and rubber gloves are required for typical daily work involving peroxide. If exposure potential is increased due to spillage, maintenance or sampling, additional items are required (vinyl acid suit, neoprene boots, full-face shield). Failure to wear the proper PPE could lead to injuries to personnel or ignition of cotton clothes or leather boots.

Any storage or handling area must be clear of combustible materials, such as wood, leaves, paper, etc.

The laboratory testing of the peroxide application to the contaminated clay did not indicate significant PCE volatilization during treatment. However, because there are a minimal number of workers involved in this implementation it is considered prudent to conduct the work in Level C PPE. This additional protection does not significantly hinder worker vision or mobility the was supplied air PPE can, so implementing a level of over-protectiveness that does not in itself make the work more difficult is considered appropriate. The Level C PPE will be carbon filter half face respirators with full face splash shield worn above. Coated non-porous tyvek suits will be required with chemical resistant steel toe boots. Chemical resistant gloves must also be worn by all site workers during application of peroxide.

The peroxide tanker will be located within the exclusion zone to prevent unauthorized contact with any of the storage equipment and delivery piping.

Always have water available whenever hydrogen peroxide is used, a reliable water source must be readily available to address spills or contact issues. Safety showers and eyewashes with potable water sources are recommended to address personnel exposure emergencies. A water hose is required to address spills, to put out fires or to cool the tank exterior in the event of decomposition.

A potable water line will be run from the warehouse out to the excavation using 1" schedule 80 PVC in order to minimize the pressure drop through the length of the supply line. Sufficient supply line will be available to reach any area of

the excavation. A portable eye wash and safety shower will also be located at a safe location within the exclusion zone.

6.4.3 H₂O₂ Storage & Handling System Mandatory Requirements

This checklist applies only to straight deliveries of < 52% Standard or Tech Grade H₂O₂. Additional restrictions apply to > 52% H₂O₂, other grades of H₂O₂, or dilution deliveries.

Requirements of the vendor providing the peroxide by bulk tanker to the Site include:

1. H₂O₂ storage tanks are constructed of 304Lsst, 316Lsst, 5254 Aluminum, or (HDPE) High Density, Cross-linked, Polyethylene
2. H₂O₂ piping is constructed of 304 or 316 ss or 1060 Aluminum. Plastic piping (e.g., PVC, Polyethylene) is approved for short-term use only.
3. All “wetted” components of the peroxide storage & handling system are compatible with hydrogen peroxide. Examples of some common materials that are not compatible with H₂O₂ are black iron, carbon steel, hastelloy, copper, brass, bronze, graphite, polypropylene, Buna-N, neoprene rubber.
4. The peroxide system is properly passivated with a nitric acid solution in accordance with passivity procedures or an approved equivalent.
5. Level indication is operable (e.g. level transmitter w/local readout, sight glass, etc.), so driver can visually monitor tank levels during delivery.
6. Peroxide storage tank is clearly labeled “__% Hydrogen Peroxide”. Fill lines, that are remote from the tank are clearly labeled.
7. Peroxide system is properly vented where peroxide could be trapped (e.g. ball valves are vented, and sections of piping between 2 valves have relief valves).
8. Tank outlet is outfitted with an isolation valve.
9. Closure devices are installed on the fill line. (i.e. valve, Q/C plug, blind flange, etc.). A locked valve is recommended.
10. All tank openings are filtered or have screens.

The following requirements apply to the maintenance of the peroxide tanker once it has been delivered to the site. These requirements are the responsibility of Ciba and its subcontractor.

1. Peroxide system is free of leaks.
2. Peroxide storage tanks are secured and inaccessible to the general public.
3. A water hose from a clean water source is available at the peroxide unloading area. A safety shower/eyewash station is strongly recommended.
4. Unloading and storage area is clear of combustible materials.
5. Storage tanks loading connections are accessible.
6. All pressurized peroxide application points (incl. submerged discharges located at elevations above the top of the H₂O₂ storage tank) are equipped with redundant backflow prevention. An atmospheric break tank between the H₂O₂ storage tank & injection point is strongly recommended for pressure injection applications.
7. Process piping does not return to the storage tank. The following exceptions are acceptable
 - Dilution water piping.
 - Tank recycle, mix or multiple peroxide tank interconnecting lines.
 - Local relief valve vent discharge piping.
 - Local siphon breaks.
 - Peroxide day tank overflow as long as return can not be contaminated.
8. Containment (e.g. dike, double-walled tank, trench system, gravel pit, etc.) is provided .

To ensure the safe delivery, storage and use of hydrogen peroxide, the supplying vendor performs an engineering assessment for each storage and handling system prior to delivery. The vendor has established the following guidelines to determine the level of evaluation required for each system.

The first outlines minimum equipment requirements for non-dilution deliveries and storage at concentrations less than 52%. The second supplements the first and outlines additional equipment requirements for storage of concentrations greater than 52% but less than 70%. The third also supplements the first and

identifies additional equipment requirements for dilution deliveries. Deliveries for concentrations greater than 70% or for other specialty grades having additional requirements.

Ciba will utilize a 50% hydrogen peroxide solution for this remedial action with no dilution system. Ciba performed an initial evaluation with the supplying vendor's engineering group to evaluate any materials handling and safety issues related to the proposed process for peroxide delivery and mixing in the excavation. A MSDS for the peroxide solution is included as an attachment to this document. The evaluation provided by the peroxide supplier as part of their product stewardship is outlined in the following table.

	Scenario	Requirement
	Delivery and storage of 70% or greater Hydrogen Peroxide	FMC technical representative reviews system design and performs site inspection and safety training. FMC Driver Technician makes first delivery.
	Delivery to new Hydrogen Peroxide user <ul style="list-style-type: none"> • all concentrations • includes customers upgrading from drum quantity to bulk systems 	FMC technical representative reviews system design and performs site inspection and safety training. FMC Driver Technician makes first delivery.
	Delivery to new system at Experienced Peroxide User <ul style="list-style-type: none"> • less than 70% 	FMC technical representative or designee reviews design package and performs site inspection. Safety training offered. FMC Driver Technician makes first delivery.
	Delivery to new FMC account that is an experienced peroxide user	Review elements of the FMC Mandatory System Requirements Checklist (completed by site personnel). Fax copy to TSED for file. FMC Driver Technician makes initial delivery.
	Delivery to FMC account where last delivery was over on year ago	Verbal review of system elements with site representative to ensure no changes was made since last delivery. Documentation of Mandatory System Requirements required if changes were made.

6.4.4 Personal protective Equipment (PPE) Requirements

PPE requirements are based primarily upon prevention of exposure to the peroxide solution, but also take into account personal protection in the wet excavation environment. Level C PPE will be utilized, which includes a full face organic cartridge respirator, non-porous protective tyvek or vinyl suit, steel toes liquid impermeable boots, and chemical resistant gloves.

6.4.5 Emergency Procedures

In the event of exposure to hydrogen peroxide, procedures on the MSDS sheet for the solution used will be followed. The route to the local emergency room and a list of emergency contacts will be reviewed by Site personnel prior to starting work.

6.4.6 Operational Monitoring

Operational monitoring will be conducted to assess the protectiveness of the PPE used by site workers during application of the peroxide and minimize environmental impacts. Photoionization detector (PID) measurements will be conducted at the excavation site in the worker breathing zone.

A combustible gas indicator (LEL/O₂) will also be used to monitor percent oxygen in the exclusion zone.

All monitoring equipment shall be used in accordance with manufacturer's directions and shall be calibrated daily.

Visual monitoring will be used to assess the rate of expansion of the treated soil caused by oxygen evolution. If the rate of clay expansion from trapped oxygen gas becomes too great then the peroxide application rate will be reduced.

6.5 Performance Monitoring

Monitoring of the performance of the oxidation of the PCE will consist of soil sampling prior to backfilling the excavation, followed by continued groundwater monitoring of both shallow and deep groundwater in and around the treatment area.

Four (4) samples of the clay will be collected in a manner to represent a composite of the treated material. These samples will be evaluated by PID field screening and also by confirmatory analysis.

The monitoring wells in this area will be added to the wells already sampled on a bi-annual basis pursuant to the March 1997 Compliance Order. Wells to be added to the program are the following:

PZ-9	PZ-11
PZ-10	MW-208
MW-404A	MW-408A
MW-401B	

These wells will be sampled approximately one month after the remedial action for the Plourde-Lyons clay has been completed. The current schedule proposes the remediation in November 2001, so the groundwater sampling will be conducted in December 2001.

7.0 List of Acronyms and Abbreviations

ABB-ES	ABB Environmental Services, Inc.
bgs	below ground surface
CAO	Corrective Action Objectives
CFR	Code of Federal Regulations
Ciba	Ciba Specialty Chemicals Corporation
cm/sec	centimeters per second
cy	cubic yards
DAF	dilution-attenuation factor
DCA	1,1-dichloroethane
DCE	trans-1,2-dichloroethene
GC	gas chromatography
H&H	Hamblet & Hayes Site
HDPE	high-density polyethylene
HQ	hazard quotient
LDR	land disposal restrictions
MEDEP	Maine Department of Environmental Protection
mg/kg	milligrams per kilogram
O&M	operation and maintenance
PCE	tetrachloroethene
ppm	parts per million
PVC	polyvinyl chloride
RAE	Remedial Action Evaluation
RCRA	Resource Conservation and Recovery Act
RTV	Reference Toxicity Value
scfm	standard cubic feet per minute
SI	Site Investigation
SSL	Soil Screening Levels
SVE	soil vapor extraction
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TSD	Treatment, Storage, and Disposal
µg/kg	micrograms per kilogram
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

8.0 References

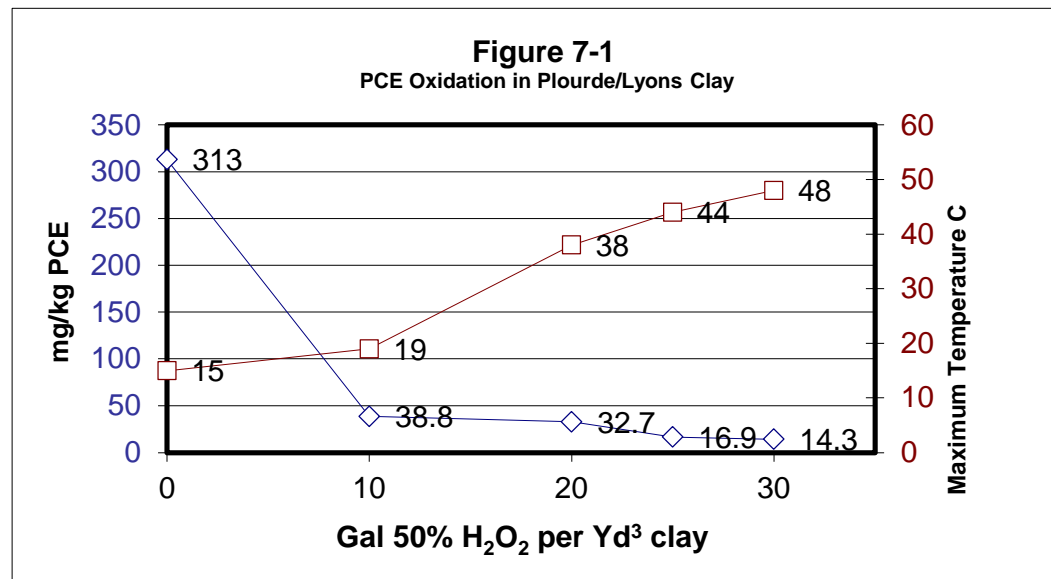
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Table 7-1
Hydrogen Peroxide Treatability Data

Initial Clay	mg/kg PCE	
Sample 1	261	
Sample 2	454	
Sample 3	223	
Mean	313	
gal H ₂ O ₂ /yd ³ clay		
(50% solution)	Residual PCE (mg/kg)	% Removal
10	44.8	99.86%
10	32.7	99.90%
20	20.3	99.94%
20	45.2	99.86%
25	22.6	99.93%
25	11.2	99.96%
30	21.7	99.93%
30	6.9	99.98%

gal/yd ³	PCE	Temp C
0	313	15
10	38.8	19
20	32.7	38
25	16.9	44
30	14.3	48











































































REPOSITORY TARGET SHEET
US EPA New England
Superfund Document Management System (SDMS)
Native Files Target Sheet

SEMS Document ID #: 638042

Site Name: CIBA-GEIGY CORP. (RID001194323)

File Type(s) Attached: .PPT; .XLS

Document Type this Target Sheet Represents:

☐ Map ☒ Photograph/Graphic ☒ Graph/Chart

☐ Video ☐ Compact Disc ☐ Other: **Word Document**

Description or Comments:

LEWISTON REMEDIATION PHOTOS AND PCE OXIDATION BENCH TESTING

**To view the attached files, open the “Attachment Panel”
by clicking on the paper clip -  - at the bottom left of this window.**

** Please note to view attachments the software corresponding with the specified file type is
necessary. **

For any additional assistance please contact the EPA New England Office of Site Remediation
and Restoration Records and Information Center-
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